

NICOLET SCIENTIFIC CORPORATION

Serial Number _____

Instruction Manual

for

MODEL 660A

DUAL - CHANNEL FFT ANALYZER



NICOLET SCIENTIFIC CORPORATION / 245 LIVINGSTON ST., NORTHVALE, N. J. 07647 (201) 767-7100

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All Nicolet Scientific instruments are warranted against defective materials and workmanship for one year. For detailed information on the warranty agreement, refer to the page at the rear of this publication for conditions and shipping instructions.

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WARNING

CONCERNING SAFE OPERATION OF ELECTRICAL EQUIPMENT:

1. This equipment is supplied with a detachable, rubber-covered electrical ac power line cord. One termination of the cord is a standard three-contact female connector for mating the AC INPUT receptacle on the instrument's rear panel. The other termination is a 3-prong male connector for mating a power source outlet, with one of the power source terminals at ground potential. **THIS EQUIPMENT SHOULD NEVER BE OPERATED UNLESS IT IS PROPERLY GROUNDED.**
2. If you use a 2-prong to 3-prong adapter for mating to your power source outlet, make sure that the pigtail lead (the grounding strap which is provided on the 2-prong adapter) is securely grounded. **FAILURE TO FOLLOW THIS WARNING MAY RESULT IN ELECTRICAL SHOCK TO OPERATING AND MAINTENANCE PERSONNEL.**
3. Nominal 115-volt or 220-volt ac potentials are present on the terminals of the front panel POWER switch and on the rear panel ac POWER INPUT connector and line protective fuse. Nominal 115-volt or 220-volt ac potentials also exist on the terminal strip of the self-contained power supply module and at various electrical terminals within the power supply module. **ALWAYS EXERCISE EXTREME CARE WHEN WORKING IN OR NEAR THESE AREAS TO AVOID SEVERE ELECTRICAL SHOCK!**
4. Lethal dc voltages are present within all Nicolet Scientific Corp. manufactured equipment utilizing switching type power supplies and CRT displays. This equipment should only be serviced by **TRAINED PERSONNEL** using extreme care to avoid severe electrical shock.

EXPERIMENTAL RATE DETERMINATION OF A CHEMICAL REACTION

This experiment is designed to determine the rate of reaction of a chemical reaction. The reaction is carried out in a closed system and the rate of reaction is determined by measuring the change in concentration of one of the reactants or products over a period of time. The rate of reaction is then compared with the theoretical rate of reaction calculated from the stoichiometry of the reaction.

If you are a student of chemistry, you will be familiar with the fact that the rate of reaction of a chemical reaction is determined by the concentration of the reactants and the temperature of the reaction mixture. The rate of reaction is also affected by the presence of a catalyst.

There are many factors which affect the rate of reaction of a chemical reaction. The most important factors are the concentration of the reactants, the temperature of the reaction mixture, and the presence of a catalyst. The rate of reaction is also affected by the surface area of the reactants.

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INSTRUCTION MANUAL NOTICE

Every effort has been made by the Engineering and Service Departments of Nicolet Scientific Corporation to present accurate, helpful, and readily understood instructions in this manual. Our goal is to assist you in the efficient operation and maintenance of your precision instrument. The following information will facilitate your use of this publication.

CORRECTIONS:

Sometimes, changes in text or descriptions of circuit design changes cannot be incorporated in the printed manual (and its schematic diagrams). In this event, we provide you with the latest data on the colored pages in this manual following this page. These colored pages cover corrections to the text or to certain of the schematic diagrams, and must be read for the manual to properly reflect the equipment you received.

DATA COVERING OPTIONAL FEATURES AND SYSTEM CONFIGURATIONS:

Data covering certain optional features of our equipment, or special system configurations are provided in the text. If you have not ordered these options, the corresponding section of the manual does not apply to the equipment you received.

EXHIBIT 100-100000

Every effort has been made by the Government of the United States to obtain the most reliable information available for the purpose of this report. The Government is not responsible for the accuracy of the information contained in this report. The Government is not responsible for the accuracy of the information contained in this report.

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CAUTION

CONCERNING RACK-MOUNTING OF EQUIPMENT:

DO NOT ATTEMPT TO RACK-MOUNT THE UBIQUITOUS SPECTRUM ANALYZER , UNLESS SUPPORT BRACKETS OR SHELVES ARE INSTALLED IN THE RACK TO SUPPORT THE UNIT. THE WEIGHT OF THE SPECTRUM ANALYZER (APPROXIMATELY 80 POUNDS, UNCRATED) REQUIRES STRUCTURAL SUPPORT, IN ADDITION TO THE FRONT PANEL MOUNTING BOLTS. SECURING THE SPECTRUM ANALYZER TO THE VERTICAL CHANNELS OF A RACK ONLY BY THE FRONT PANEL WILL RESULT IN DAMAGE TO THE EQUIPMENT!

F O R W A R D

This manual provides operating instructions for the Model 660 Dual-Channel FFT Processor. These instructions introduce the Model 660 controls on a function-group/by/function-group basis. The order of control introduction follows the flow of selections in normal operation. It is recommended that these instructions be read in their entirety before attempting to operate the equipment.

SECTION 19

DIGITAL INTERFACES TO THE 660

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SECTION 1

OVERALL SPECIFICATIONS

FUNCTIONS CALCULATED AND DISPLAYED	FIVE MEASUREMENT MODES (Traces x no. of data points displayed in each)			
	# 1 SIG. ENH.	# 2 CH A 2K	# 3 DUAL 1K or # 4 CORR ⁽³⁾	# 5 PROB
Input Time History (IT) Averaged Time History (AT)	2x1024 ⁽¹⁾ 2x1024 ⁽¹⁾	1x2048	2x1024 ⁽¹⁾	2x1024 ⁽¹⁾
Avg. Linear Spectrum (IS)	2x400			
Inst. Spec. of Input (IS)		1x800	2x400	
RMS Spectrum (RS)		1x800	2x400	
Power Spectrum (PS)		1x800	2x400	
Cross Spectrum (CS)			1x400 ⁽²⁾	
Transfer Function (TF) Equalized Trans. Function(ETF)			1x400 ⁽²⁾ 1x400 ⁽²⁾	
Transmissibility Function (TM) Equal. Transmiss. Function(ETM)			1x400 1x400	
Coherence Function (COH) Coherent Output Power (CP)			1x400 1x400	
Impulse Response (IR) Equalized Impulse Resp.(EIR)			1x1024 1x1024	
Auto Correl. Function (ACF) Cross Correl. Function (CCF)			2x1024 1x1024	
Prob. Density Function (PDF) Cumulative Dist. Function(CDF)				2x127 2x127
NUMBER OF FUNCTIONS AVAILABLE WITHOUT CHANGING MODES OR RERUNNING DATA	6	4	20	6

FOOTNOTES:

- (1) 1024 data points A vs. B in "NYQ"
 (2) Complex data points; 400 real and 400 imaginary, or 400 magnitude and 400 phase, or 400 Nyquist (R vs. I)
 (3) Weighting removed and pad-zeros applied in correlation

INPUT CHARACTERISTICS (Each Input Channel)

MAXIMUM AMPLITUDE - 0 1, 0.2, 0.5, 1, 2, 5, 10, 20 V (0 - peak)

COUPLING - AC (-3 dB at 0.5 Hz) or DC, normal or digitally inverted, digital ZERO is effective input ground.

IMPEDANCE - 100K ohms

TEST SIGNALS - (a) Single peak, approximately full scale amplitude, appears in each channel at 64% of analysis range (normal input is disconnected when test signal is on). (b) (Rear panel) Digitally generated random and digitally filtered random noise outputs provide standard complex functions regardless of frequency range; random sequence over 1,000,000 samples, clocked in sync with input ADC; amplitude 0-1V; trigger restarts sequence after pre-sequence of 2048 samples to create pseudo-random noise

INPUT SAMPLING: 12-bit A/D conversion at 2.56 times maximum frequency in the range selected; 256,000 per second maximum external control.

INPUT FILTERS: Range switch automatically selects a pair of matched, low-pass, anti-aliasing filters, which provide at least 70 dB attenuation of those input frequencies which can cause aliasing (10 Hz filter used on 1, 2 and 5 Hz ranges); frequency response ± 0.5 dB (except ± 1.0 dB on 100 kHz range).

TRANSIENT CAPTURE CONTROL: Digital data in input buffer memories held manually by placing the HOLD/REL button in HOLD (light on), or automatically by triggering on the transient waveform in either A or B input channels at a preset trigger level ($\pm 1/2$, $\pm 1/4$, $\pm 1/8$, or $\pm 1/16$ FS) after ARM is pushed (light on); anticipation or delay of the trigger set using the keyboard (T $\rightarrow$ A) from -1 to 63 time windows.

INPUT AMPLITUDE MONITORS: Lights indicate peak signal levels - OVERLOAD, -6 dB (greater than 1/2 full

scale), -12 dB (between 1/2 and 1/4 FS), -18 dB (between 1/4 and 1/8 FS), -24 dB (between 1/8 and 1/16 FS); electronic graticule top and bottom in time display indicates amplitude limits.

FREQUENCY RANGES: (any other coverage up to 100 kHz can be set using external sampling at 2.56 x Fmax and calibrated to read correctly using ORDERS; the anti-aliasing low-pass input filters associated with the range switch appear in the signal paths).

RANGE (Hz)	DUAL 1K MODE* NOMINAL BW (Hz)	TIME WINDOW* (SEC)
100K	250	.004
50K	125	.008
20K	50	.02
10K	25	.04
5K	12.5	.08
2K	5.0	.2
1K	2.5	.4
500	1.25	.8
200	0.5	2
100	0.25	4
50	0.125	8
20	0.05	20
10	0.025	40
5	0.0125	80
2	0.005	200
1	0.0025	400

* For CH A 2K mode, nominal BW is X 1/2, time window is X2; BW is also lowest frequency that can be read.

STORED FUNCTIONS (Internal Memory):

STORE - retains one 800-line spectrum, one 1024-sample time waveform, or two 400-line spectra on display; for cross-spectrum or TF, stores R and I regardless of display

RECALL - displays stored data; reverts back to current date display upon second actuation of pushbutton (LED off)

COMPARE - displays one stored trace and corresponding current traces if both processed in a similar manner.

EQL TF/TM - Equalizes current transfer function with stored TF (if both processed in a similar manner) by dividing magnitude of current by stored and subtracting phase of stored from current; also equalizes IR and TM.

BUILT-IN ANNOTATED DISPLAY:

VERTICAL DISPLAY - linear full scale can be set to 1, 1 25, 1.5, 2, 2.5, 3, 4, 5, 6 or 8×10^6 , or to cursor amplitude, or to other number entered with keyboard; log offset from +300 dB to -300 dB in 10 dB steps, display range from 20 dB to 160 dB in 20 dB steps via keyboard (DSPL dB).

TIME DISPLAYS - self-aligning electronic graticule; input maximum amplitude written on CRT in volts 0 - peak

FREQUENCY DISPLAYS - self-aligning electronic graticule; annotation includes display and scaling as well as input settings and running N of average if recalled.

DISPLAY FORMATS: Time A vs. time B; single or dual channel where applicable; cross-spectra magnitude and/or phase, real and/or imaginary, or real vs. imaginary (Nyquist); for frequency, lin/log vertical and horizontal.

CALIBRATION AT CURSOR:

MARKER - single line cursor intensifies each waveform at its intersection to indicate location of measurement; in HARMONIC multiples of cursor frequency are illuminated with multiple dots.

AMPLITUDE E, E² or dB E (engineering units) using keyboard to establish E at cursor or sensitivity as V/E; reference (R) set for relative measurements; V, V² (power) or dB V; readings normalized per Hz (such as PSD) using the per Hz button

FREQUENCY - Hz (cycles/sec), CPM (cycles/minute), cell number, fraction of FS or orders; reads absolute or as difference from reference frequency.

TIME - sec, msec, fraction of FS, cell number or cycles (1/orders).

KEYBOARD SETTINGS: (Set and recalled)

AVG N - number of functions averaged (1 - 9999); running N can be displayed.

DLY T $\rightarrow$ A - delay (or anticipation) between trigger signal and start of Channel A data window set in time windows from -1.000 to +63.000.

DLY A $\rightarrow$ B - delay introduced between Channels A and B in time windows 0 to 64.000

PNL - stores 9 sets of complete panel settings with ID numbers for recall (see below).

CUR LOC - 9 cursor locations stored with ID numbers for recall

RMS 1-2 - calculates total RMS power between any two stored cursor locations; cursor alternates between two locations in display

$\int dt$, d/dt - effective time-domain integration or differentiation, single or double affects all functions until cleared (e.g. converts acceleration to velocity to displacement).

COH BLANK - sets level of display blanking based on degree of coherence (0 - 1.00)

PLOT RATE - five X-Y plot speeds from very slow (#1) to very fast (#5).

DSPL dB - 20 dB to 160 dB in 20 dB steps.

LIN - amplitude at cursor on CH A or CH B set to a linear reference (recall is in V/EU)

dB - amplitude at cursor on CH A or CH B set to a dB reference (recall is in V/EU).

V/EU - calibration sensitivity of CH A or CH B set in engineering units.

FREQ REF - cursor location set in the units of the display, to which all future cursor locations are referenced.

ORDER REF - cursor location set (in ORD), scaling future cursor locations proportionally (for example, if cursor at .1 FS is assigned "30", then FS will be "300")

DEFINE AUX - auxiliary codes used for secondary operations.

PANEL STORAGE (PNL) - stores and recalls nine sets of setup, processing and display settings

CURSOR TYPE	COHERENCE BLANK
FREQ READ	PLOT RATE
DISPLAY GAIN (offset)	DISPLAY dB
AVERAGE MODE	INPUT AMPLITUDE
AVERAGE N	Jdt, d/dt
DELAY T→A	AUX CODE
DELAY A→B	CAL V/EU (CH A and CH B)
MODE	CAPTURE CONTROL
FUNCTION	FREQ REF
DISPLAY CH	ORDER REF
DISPLAY FORMAT	XPND WIDTH*
DISPLAY MEMORY	XPND (location)*

* with -2D Digital Expansion

NUMERIC CALCULATION: Numbers in entry field, manually entered or transferred from another field can be added, subtracted, multiplied or divided, or the square root or reciprocal taken

AVERAGING (9 types):

SUM adds N power spectra (N = 1 - 9999 set with keyboard); redundancy selectable 0% or 50%.

DIFF subtracts N power spectra from previous average.

EX follows the changing statistics of a signal exponentially with a time constant of (N) x (time window)

PEAK produces the profile of the maximum amplitudes at each frequency element during N spectra.

SWEEP averages with maximum redundancy

TRANS averages power spectra of N transients automatically in SUM, DIFF, EX or PK modes, except those which overlaid input; after each capture, the transient trigger is automatically re-armed; used for time averaging

AVERAGING CONTROL:

START erases memory and starts averaging

STOP halts averaging.

CONT resumes averaging until N is reached; if averaging completed, restarts averaging without erasing memory

ANALOG OUTPUTS: X, Y and Z outputs for external CRT display; X, Y and pen lift for X-Y plotters; timing pulses for 3-D display (see Model 66-2A); PLOT CAL provides lower-left end upper-right of grid for setup; output of amplitude at cursor

DIGITAL INTERFACES (Standard Built-In):

- a Full duplex RS232 serial interface with selectable baud rates of 110, 150, 300, 600, 1200, 2400, 4800, 9600; internal programming communicates with digital plotters through the RS232 interface; when used to communicate with external devices, the outputs from the RS232 interface are printable in ASCII characters
- b IEEE488-1975 interface (full listener/talker)
- c High-speed 12-bit A/D converter output interface using 16-bit parallel words (two channels simultaneously); 16-bit digital input to time buffer.

POWER: 425 watts, 600 VA

WEIGHT: 36.4 kgm (80 pounds) nominal

SIZE: 35.56 cm (14 in.) high, 43.18 cm (17 in.) wide, 52.79 cm (20-7/8 in.) deep

AVAILABLE OPTIONS:

TEXT ENTRY -6 (Built-In): Allows 4 lines of 42 alphanumeric characters and punctuation to be entered, edited, and positioned anywhere in the display and plotted, turned on or off selectively and displayed with or without other annotation, graticule, or data.

DIGITAL ("ZOOM") EXPANSION -2D (Built-In): Expansion by X8 to X512 on 13 ranges from 0 - 10 Hz to 0 - 100 kHz allowing 13 input filter choices; analysis windows from .64 Hz - 12.8 Hz; 47 bandwidths from .8 mHz to 32 Hz.

DIGITAL PLOTTING ADAPTER MODEL 136A: Produces hardcopy 8-1/2" x 11" or 11" x 17" of the display on fanfold paper; paper can be made to automatically advance at end of plot; multi-color plots produced with pen changes between successive displays with controlled data or annotation blanked (AUX codes).

DATA RECORDER ADAPTER MODEL 160 : Dual mini-floppy disk digital storage of complete functions, annotations, and setup/display settings; search by entered ID number or number "mask", or by sequential file number.

MODAL ANALYSIS MA-2: Extracts modal parameters and displays dynamics of each mode on stored test object geometry. (Modal Analysis and 660A-2D designated as Modal Analysis System 6601A.)

HAMMER KIT MODEL 52: Hammer with force transducer mounted in its head plus accelerometer for impulse testing.

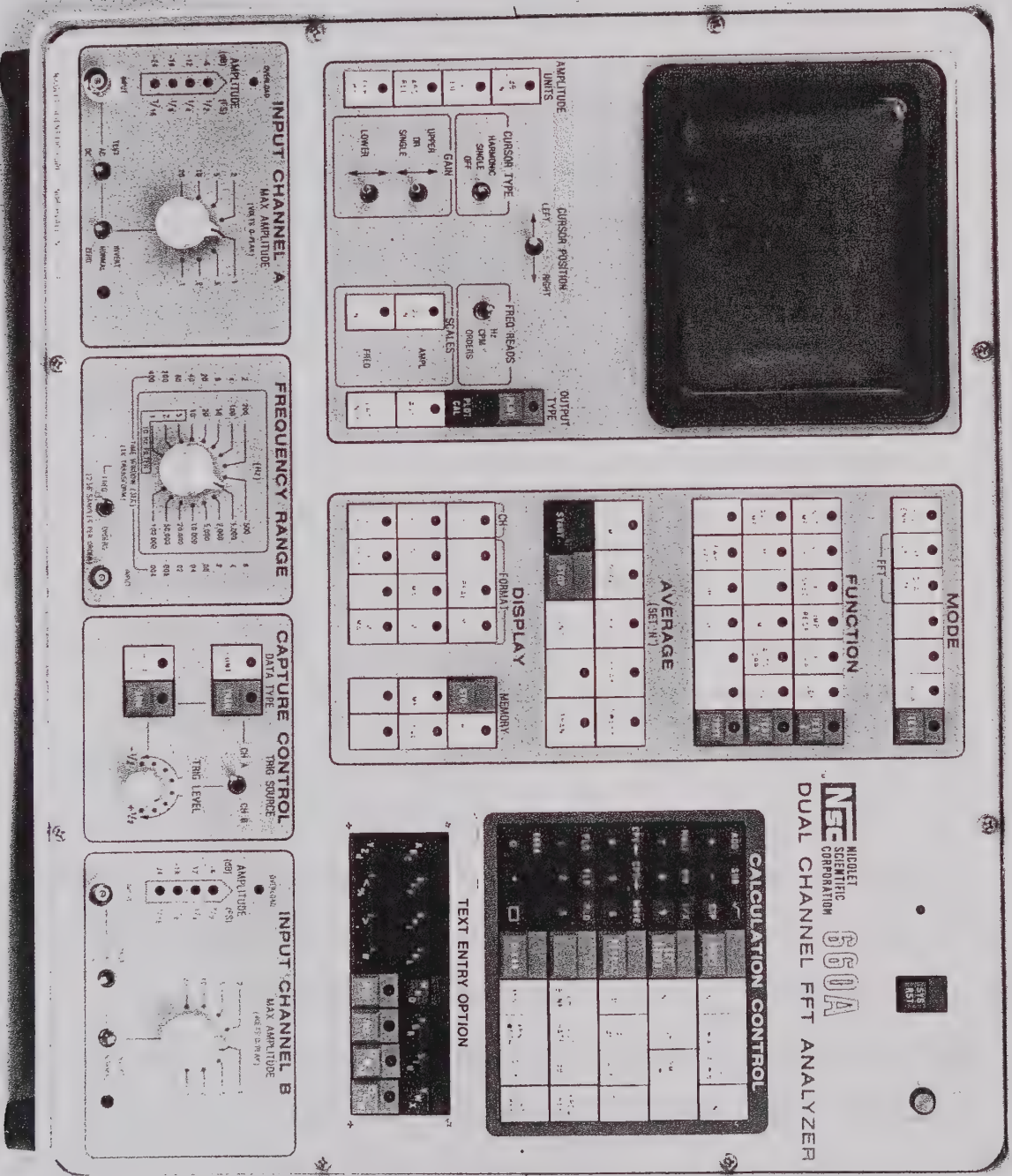
SPECTRUM TRACKING ADAPTER MODEL 24C: Converts tachometer or other input rates to correct sampling rate to display number of orders desired.

RECORDING ADAPTER MODEL 61: Polaroid camera with special bezel adapter.

3-D DISPLAY GENERATOR MODEL 66-2A: Time history display of successive traces one under the other stored on companion Tek 613 large-screen storage display.

X-Y PLOTTER MODEL 131B: Portable X-Y plotter.

TRANSIT CASE MODEL 99L: Roll-around re-useable case for shipment.



SECTION 2

GENERAL CHARACTERISTICS OF THE FRONT PANEL

2.0 Characteristics

Figure 2A illustrates the front panel of the Model 660. Controls are arranged in logical function groups. The majority of front panel controls are momentary contact push-button switches. Many of these switches have a light emitting diode (LED) in the center of the pushbutton. An illuminated LED indicates that the particular control is in an on state. Unless a control's LED is illuminated, its function should be assumed to be off. Five of the control pushbuttons (three under AMPLITUDE UNITS and two under SCALES) have a horizontal line on their face. These controls provide either-or (/) choices.

The instrument has a front panel provision to accept two analog data signals and, optionally, an externally generated sample rate. The results of analyses are presented on the built-in cathode ray tube (CRT) located in the upper lefthand corner of the front panel. Additionally, analog and digital signals are provided on the rear panel, Figure 2B, for hard-copy of screen images as well as external digital communication. Table 2-1 gives the characteristics of the rear panel signals.

LETHAL VOLTAGES EXIST WITHIN THIS INSTRUMENT
TO BE SERVICED BY QUALIFIED PERSONNEL ONLY

WARNINGS

1. J111-IEEE 488

2. J112-RS232-C

3. J113-PARALLEL A/D

4. J114-PARALLEL INTERFACE

5. J115-X

6. J116-Y

7. J117-Z

8. J118-X

9. J119-Y

10. J120-PEN LIFT

11. J121-IEEE 488

12. J122-RS232-C

13. J123-PARALLEL A/D

14. J124-PARALLEL INTERFACE

15. J125-X

16. J126-Y

17. J127-Z

18. J128-X

19. J129-Y

20. J130-PEN LIFT

21. J131-IEEE 488

22. J132-RS232-C

23. J133-PARALLEL A/D

24. J134-PARALLEL INTERFACE

25. J135-X

26. J136-Y

27. J137-Z

28. J138-X

29. J139-Y

30. J140-PEN LIFT

31. J141-IEEE 488

32. J142-RS232-C

33. J143-PARALLEL A/D

34. J144-PARALLEL INTERFACE

35. J145-X

36. J146-Y

37. J147-Z

38. J148-X

39. J149-Y

40. J150-PEN LIFT

41. J151-IEEE 488

42. J152-RS232-C

43. J153-PARALLEL A/D

44. J154-PARALLEL INTERFACE

45. J155-X

46. J156-Y

47. J157-Z

48. J158-X

49. J159-Y

50. J160-PEN LIFT

51. J161-IEEE 488

52. J162-RS232-C

53. J163-PARALLEL A/D

54. J164-PARALLEL INTERFACE

55. J165-X

56. J166-Y

57. J167-Z

58. J168-X

59. J169-Y

60. J170-PEN LIFT

61. J171-IEEE 488

62. J172-RS232-C

63. J173-PARALLEL A/D

64. J174-PARALLEL INTERFACE

65. J175-X

66. J176-Y

67. J177-Z

68. J178-X

69. J179-Y

70. J180-PEN LIFT

71. J181-IEEE 488

72. J182-RS232-C

73. J183-PARALLEL A/D

74. J184-PARALLEL INTERFACE

75. J185-X

76. J186-Y

77. J187-Z

78. J188-X

79. J189-Y

80. J190-PEN LIFT

81. J191-IEEE 488

82. J192-RS232-C

83. J193-PARALLEL A/D

84. J194-PARALLEL INTERFACE

85. J195-X

86. J196-Y

87. J197-Z

88. J198-X

89. J199-Y

90. J200-PEN LIFT

91. J201-IEEE 488

92. J202-RS232-C

93. J203-PARALLEL A/D

94. J204-PARALLEL INTERFACE

95. J205-X

96. J206-Y

97. J207-Z

98. J208-X

99. J209-Y

100. J210-PEN LIFT

101. J211-IEEE 488

102. J212-RS232-C

103. J213-PARALLEL A/D

104. J214-PARALLEL INTERFACE

105. J215-X

106. J216-Y

107. J217-Z

108. J218-X

109. J219-Y

110. J220-PEN LIFT

111. J221-IEEE 488

112. J222-RS232-C

113. J223-PARALLEL A/D

114. J224-PARALLEL INTERFACE

115. J225-X

116. J226-Y

117. J227-Z

118. J228-X

119. J229-Y

120. J230-PEN LIFT

121. J231-IEEE 488

122. J232-RS232-C

123. J233-PARALLEL A/D

124. J234-PARALLEL INTERFACE

125. J235-X

126. J236-Y

127. J237-Z

128. J238-X

129. J239-Y

130. J240-PEN LIFT

131. J241-IEEE 488

132. J242-RS232-C

133. J243-PARALLEL A/D

134. J244-PARALLEL INTERFACE

135. J245-X

136. J246-Y

137. J247-Z

138. J248-X

139. J249-Y

140. J250-PEN LIFT

141. J251-IEEE 488

142. J252-RS232-C

143. J253-PARALLEL A/D

144. J254-PARALLEL INTERFACE

145. J255-X

146. J256-Y

147. J257-Z

148. J258-X

149. J259-Y

150. J260-PEN LIFT

151. J261-IEEE 488

152. J262-RS232-C

153. J263-PARALLEL A/D

154. J264-PARALLEL INTERFACE

155. J265-X

156. J266-Y

157. J267-Z

158. J268-X

159. J269-Y

160. J270-PEN LIFT

161. J271-IEEE 488

162. J272-RS232-C

163. J273-PARALLEL A/D

164. J274-PARALLEL INTERFACE

165. J275-X

166. J276-Y

167. J277-Z

168. J278-X

169. J279-Y

170. J280-PEN LIFT

171. J281-IEEE 488

172. J282-RS232-C

173. J283-PARALLEL A/D

174. J284-PARALLEL INTERFACE

175. J285-X

176. J286-Y

177. J287-Z

178. J288-X

179. J289-Y

180. J290-PEN LIFT

181. J291-IEEE 488

182. J292-RS232-C

183. J293-PARALLEL A/D

184. J294-PARALLEL INTERFACE

185. J295-X

186. J296-Y

187. J297-Z

188. J298-X

189. J299-Y

190. J300-PEN LIFT

191. J301-IEEE 488

192. J302-RS232-C

193. J303-PARALLEL A/D

194. J304-PARALLEL INTERFACE

195. J305-X

196. J306-Y

197. J307-Z

198. J308-X

199. J309-Y

200. J310-PEN LIFT

201. J311-IEEE 488

202. J312-RS232-C

203. J313-PARALLEL A/D

204. J314-PARALLEL INTERFACE

205. J315-X

206. J316-Y

207. J317-Z

208. J318-X

209. J319-Y

210. J320-PEN LIFT

211. J321-IEEE 488

212. J322-RS232-C

213. J323-PARALLEL A/D

214. J324-PARALLEL INTERFACE

215. J325-X

216. J326-Y

217. J327-Z

218. J328-X

219. J329-Y

220. J330-PEN LIFT

221. J331-IEEE 488

222. J332-RS232-C

223. J333-PARALLEL A/D

224. J334-PARALLEL INTERFACE

225. J335-X

226. J336-Y

227. J337-Z

228. J338-X

229. J339-Y

230. J340-PEN LIFT

231. J341-IEEE 488

232. J342-RS232-C

233. J343-PARALLEL A/D

234. J344-PARALLEL INTERFACE

235. J345-X

236. J346-Y

237. J347-Z

238. J348-X

239. J349-Y

240. J350-PEN LIFT

241. J351-IEEE 488

242. J352-RS232-C

243. J353-PARALLEL A/D

244. J354-PARALLEL INTERFACE

245. J355-X

246. J356-Y

247. J357-Z

248. J358-X

249. J359-Y

250. J360-PEN LIFT

251. J361-IEEE 488

252. J362-RS232-C

253. J363-PARALLEL A/D

254. J364-PARALLEL INTERFACE

255. J365-X

256. J366-Y

257. J367-Z

258. J368-X

259. J369-Y

260. J370-PEN LIFT

261.

INPUT AC VOLT	FUSE RATING (AMP SB)	
	MIN	MAX
90	130	2.5
180	260	1.25
		15.0
		8.0

TABLE 2-1

REAR PANEL CONNECTIONS

CONNECTOR	LABEL	FUNCTION/CHARACTERISTIC
J101	DISPlay TRIGger OUT	Low TRUE TTL pulse indicating start of a new display cycle.
J102	SPARE	
J103	DISPlay GATE OUT	High TRUE TTL level indicating data on display distinct from annotation or graticule on display.
J104	FILTERED NOISE OUT	Analog signal used as a test point. Level is 0 to 1 volt peak-to-peak with a notch at approximately 55% of the analyzer range.
J105	Non Redundant TRIGger OUT	Low TRUE TTL pulse indicating start of a new display cycle with new data.
J106	NOISE RESET TRIGger IN	Low TRUE TTL pulse causes the pseudo-random binary noise generation to reset.
J107	MEMory TRIGger IN	Low TRUE TTL input pulse causes the 660 to initiate the capture of a buffer of input data. Enabled by DEFine AUXiliary 12 and 13.

TABLE 2-1 (Con't.)

REAR PANEL CONNECTIONS

CONNECTOR	LABEL	FUNCTION/CHARACTERISTIC
J108	NOISE READY TRIGger OUT	Low TRUE TTL pulse used as input to J107 when a specific repeatable binary sequence is required as a system stimulus.
J109	SPARE	
J110	BINARY NOISE OUT	Analog signal generated by a pseudo-random binary noise generator. This signal has a flat frequency spectrum and is useful as a system stimulus. The signal level is 0 to 1 volt peak-to-peak.
J111	IEEE 488	Refer to Section 19
J112	RS232-C	Refer to Section 19
J113	PARALLEL A/D	Refer to Section 19
J114	PARALLEL INTERFACE	Refer to Section 19
J115	X TO EXTERNAL DISPLAY	Analog signal 0 to 1 volts output for external CRT horizontal.
J116	Y TO EXTERNAL DISPLAY	Analog signal 0 to 1 volts output for external CRT vertical.
J117	Z TO EXTERNAL DISPLAY	Bi-level output signal for external CRT Z-axis blanking. 0 Volt indicates beam on, -2 Volts indicates beam off.

TABLE 2-1 (Con't.)

REAR PANEL CONNECTIONS

CONNECTOR	LABEL	FUNCTION/CHARACTERISTIC
J118	X TO XY PLOTTER	Analog output signal for XY plotter horizontal. Signal level 0 to 5 volts.
J119	Y TO XY PLOTTER	Analog output signal for XY plotter vertical. Signal level 0 to 5 volts.
J120	PEN LIFT TO XY PLOTTER	Relay closure. Short for pen down. Open circuit for pen up.

With line power applied to the rear panel line cord mating receptacle, the instrument may be turned on by depressing the POWER pushbutton in the upper righthand corner of the instrument. When power is initially applied, the instrument "wakes up" in dual channel processing mode, displaying the instantaneous spectra (with log amplitude vs. linear frequency) of the applied input signals. Depressing the SYS RST pushbutton, adjacent to the POWER switch, will also cause the instrument to return to its "wake up" state. See Section 17.

Turning the power off or initiating a system reset will cause the instrument to clear all stored data. The instrument will retain, however, up to ten previously defined operating states. This storage is restricted to the control settings only.

GENERAL CHARACTERISTICS OF THE DISPLAY

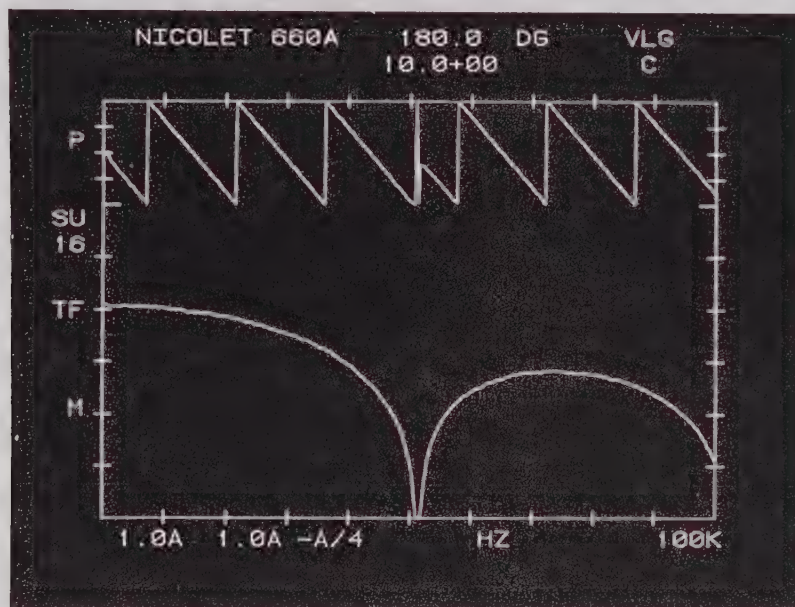
3.0 Display Characteristics

Figure 3 illustrates a typical CRT display. The display consists of data reflecting the results of computation as well as an electronically drawn graticule and annotation reflecting the control status of the instrument. Additionally, the CRT serves as a communication interface between the user and the instrument.

The annotation NICOLET 660A appearing in the upper lefthand corner of the display, is in the instrument's entry/recall field. This section of the display is reserved for messages defining the status of the instrument. For example, whenever the instrument is operating in its "wake up" state,

the annotation NICOLET 660A will appear. Three types of information may appear in the entry/recall field:

1. A summary of the most recent transaction conducted through the calculation control group, or
2. A status message informing the user that an operation has been accomplished or informs the user a particular mode of operation is ongoing, or
3. An error message indicating that the user has attempted to perform an operation outside the context of the instrument's repertoire.

Error messages require corrective action on the part of the operator. These messages are in English and instruct the operator as to the corrective action that is necessary.

Error messages are distinguishable from status messages and calculation control summaries because they are presented in inverted characters. That is, all error messages are presented in dark characters against a white background while normal status messages are presented in light characters against a dark background.

The instrument has the capability to reproduce the CRT display, in its entirety, on the optional Model 134A Digital Plotter and the optional Model 136A Digital Plotting Adapter. This same information can also be recorded using the Model 61 Polaroid Recording Adapter. Additional facility is provided to record the data traces only, on an ordinary analog X-Y plotter. Digital interface capabilities provide for the transmission of the information content, to external digital devices such as the optional Model 160B Data Recorder Adapter.

SECTION 4

OPERATING MODE CONTROL GROUP

4.0 Operating MODE

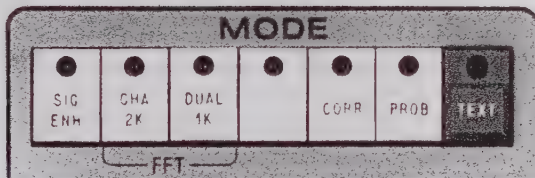


FIGURE 4

Figure 4 illustrates the operating mode control group located in the top central portion of the front panel. One of five operating modes may be selected by depressing the appropriate pushbutton control. The selected mode of operation is indicated by its associated LED. Selection of an operating mode determines what functions of the input data are computed.

Reading from left to right, the five operating modes are:

1. SIG ENH, Signal enhancement; providing dual channel, 1024 point resolution, time domain analysis.

2. CHA 2K, Channel A Fast Fourier Transform; providing single channel, data from channel A, time and frequency domain analyses. Frequency functions are provided with a resolution of 800 points while time domain functions are provided with a resolution of 2048 (2K) points.
3. DUAL 1K, 1K Channel AB Dual Fast Fourier Transform; providing dual channel processing in the time and frequency domains. Frequency domain functions are presented with a resolution of 400 points while time domain functions are presented with a resolution of 1024 (1K) points.
4. CORR, Correlation; providing the same general characteristics as the preceding mode with parameters optimized for auto and cross correlation functions.
5. PROB, Probability; providing dual channel analysis in the time and amplitude domains. Amplitude domain functions are presented with a resolution of 127 points while time domain functions are presented with a resolution of 1024 points.

The functions available in each mode are summarized in Table 4-1. Note that correlation functions are available

TABLE 4-1

AVAILABLE FUNCTIONS BY MODE

FUNCTION	MODE				
	Signal Enhancement	2K FFT (CH A Only)	1K FFT (A, B Dual)	Correlation	Probability
Input Time History	A & B	A	A & B	A & B	A & B
Averaged Time History	A & B				
Impulse Response			✓	NR	
Instant Spectrum	(1)	A	A & B	NR	
RMS Spectrum		A	A & B	NR	
Power Spectrum		A	A & B	NR	
Coherent Output Power Spectrum			✓	NR	
Cross Spectrum			✓	NR	
Transfer Function			✓	NR	
Transmissibility Function			✓	NR	
Coherence Function			✓	NR	
Auto Correlation Function			NR	✓	
Cross Correlation Function			NR	✓	
Probability Density Function					A & B
Cumulative Distribution Function					A & B

- A Single Channel Function Available for Channel A Only
 A&B Single Channel Function Available for Channels A and B
 ✓ Cross Property Function Available and Optimized
 NR Cross Property Function Available but Not Recommended
 (1) In this mode only, it provides instant spectra of averaged time histories for both A and B channels.

in the 1K channel AB fast Fourier transform mode but that certain processing parameters may not be optimized for these functions. Conversely, in the correlation mode, all of the 1K channel AB FFT functions are also available. In the correlation mode these functions will be compromised. Hence, correlation mode should be selected if correlation functions are of fundamental interest; 1K channel AB FFT mode should be selected for all other cross property functions.

In the "wake up" state the instrument automatically selects the 1K channel AB FFT mode.

FREQUENCY RANGE CONTROLS

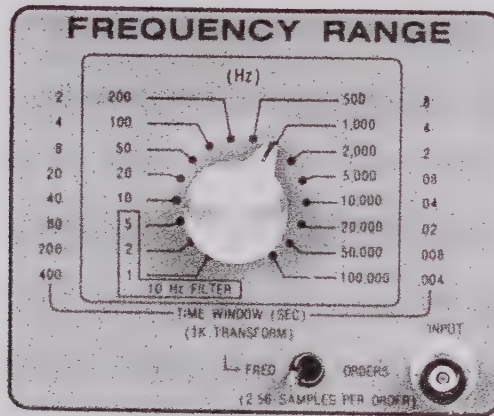
5.0 FREQUENCY RANGE Controls

FIGURE 5A

Figure 5A illustrates the frequency range control group located in the lower central portion of the front panel. Sixteen frequency ranges between 1 Hz and 100 kHz full scale may be selected in a 1, 2, 5 progression. The selected frequency range is the maximum frequency analyzed in FFT processing modes. The outer annotation surrounding the frequency range switch specifies the duration of the memory load period in seconds associated with a single 1024 point transform. The memory load period in 2K FFT mode is twice this duration.

The setting of the frequency range switch determines the sample rate at which the data is acquired, for internal

sampling, and the bandwidth of the anti-aliasing filters preceding the instrument's analog-to-digital converters. Note that selecting the 1, 2, or 5 Hz range activates the instrument's 10 Hz anti-aliasing filter. When operating on these frequency ranges, external anti-aliasing filters should be provided.

The internal sample rate provided by the analyzer is always equal to 2.56 times the selected frequency range. The internal sample rate is provided automatically when the FREQ/ORDERS switch is in the FREQ position. Placing this switch in the ORDERS position allows the instrument to operate with an external sample rate. The external sample rate is applied through the front panel INPUT BNC connector. When operating with an external sample rate, the maximum frequency analyzed is equal to the sample rate divided by 2.56. The external sample rate does not have to be constant in frequency. This facility is particularly useful in the analysis of rotating machineries.

When operating with the FREQ/ORDERS switch in the ORDERS position, the frequency range control determines the anti-aliasing filter preceding the analog-to-digital converters. If external tracking anti-aliasing filtering is provided, the frequency range selector should be placed in the 100 kHz position.

Settings of the FREQUENCY RANGE and FREQ/ORDERS controls are annotated on the CRT display. When frequency functions are selected, Figure 5B, the axis label HZ indicates that the FREQ/ORDERS switch is in the FREQ position. Placing this switch in the ORDERS position changes the axis label to OR. The setting of the frequency range switch is always annotated on the extreme righthand edge of the axis. When external sampling is used, this annotation indicates the anti-aliasing filter used.

Figure 5C illustrates the CRT display of a time function. The horizontal axis label SEC indicates that the horizontal axis is in seconds. When the FREQ/ORDERS switch is in the ORDERS position, this label changes to SMP indicating that the horizontal readout is in samples. The time period of the display (memory load period) is indicated at the extreme right of the horizontal axis. When external sampling is selected, this annotation reverts to the setting of the FREQUENCY RANGE switch, indicating the bandwidth of the anti-aliasing filters in Hz.

Figure 5D illustrates a cumulative probability distribution function amplitude domain display. The setting of the FREQUENCY RANGE switch is annotated in the upper righthand corner.

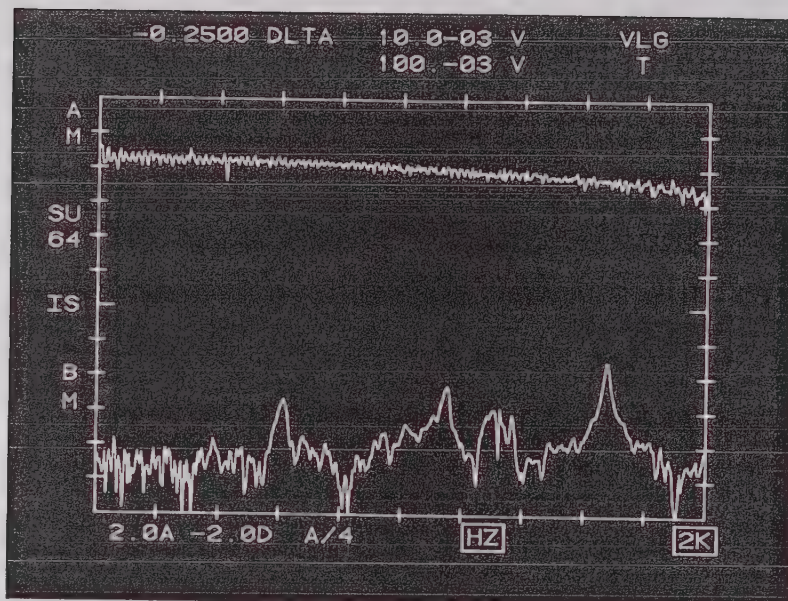


FIGURE 5B

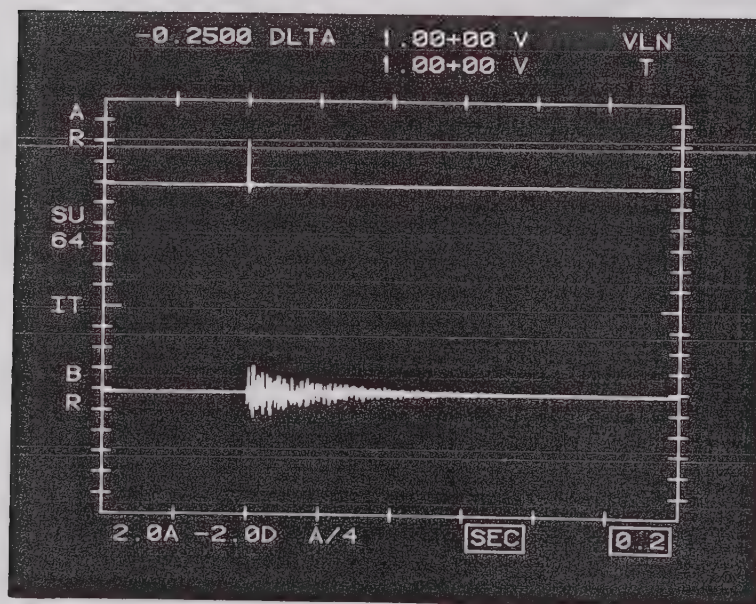


FIGURE 5C

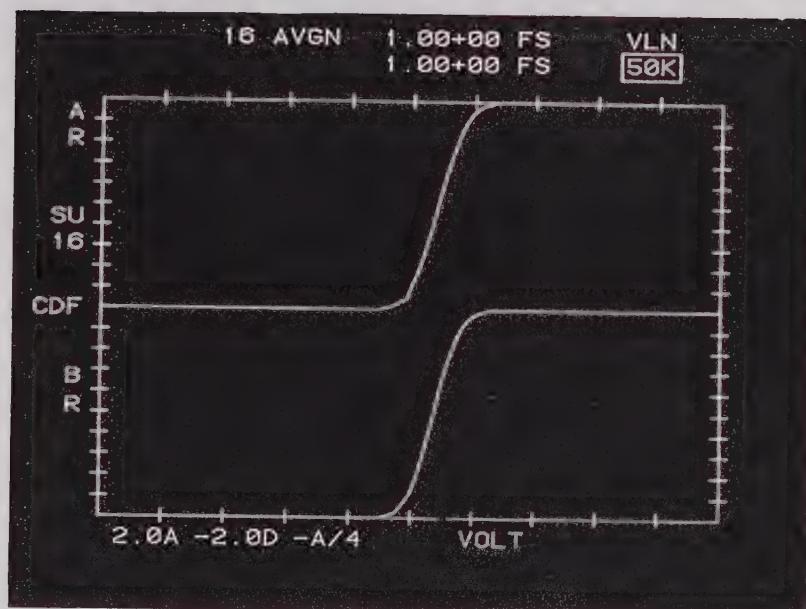


FIGURE 5D

SECTION 6

INPUT CHANNEL A AND INPUT CHANNEL B CONTROL GROUPS

6.0 INPUT Control Groups

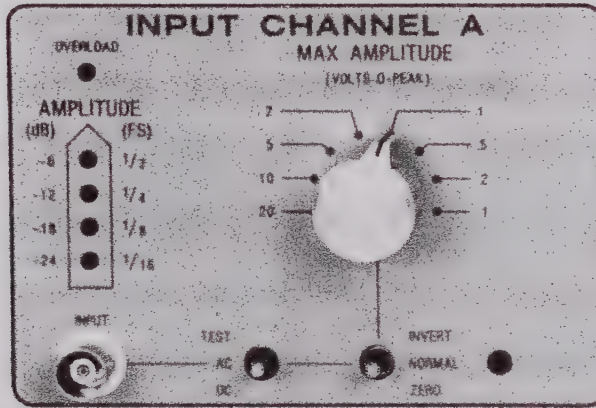


FIGURE 6A

Figure 6A illustrates one of two identical input control groups located in the lower corners of the front panel. The data signal to be analyzed is applied to the input BNC connector. AC or DC coupling may be selected, or a test signal may be substituted for the input. When AC coupling is selected, the 3 dB point is located at less than 1 Hz. When the test signal is selected, a periodic signal at 64% of the selected analysis range is applied. When the zoom is activated the test signal appears at 65.5% of the baseband display.

The signal may be analyzed as applied (normal) or it may be inverted. Inverting the signal changes the sign

of its amplitude. Alternatively, an input ZERO may be selected. Selecting an input ZERO provides a digital zero code output from the analog-to-digital converter but does not affect the electrical characteristics of the input BNC.

The MAX AMPLITUDE selector provides eight choices of input sensitivity from .1 volt to 20 volts (0-PEAK) in a 1, 2, 5 progression. Proper setting of the MAX AMPLITUDE control is achieved by viewing the AMPLITUDE LEDs. Proper setting of the MAX AMPLITUDE control is achieved when the OVERLOAD LED is off and as many of the remaining LEDs as possible (signal dependent) are on.

Settings of the input controls are annotated on the CRT image as shown in Figure 6B. These annotations always appear in the lower lefthand corner of the display. Annotation for channel A (left channel) appears on the left side. Annotation for channel B appears on the right side. If the signal has been inverted a minus sign is displayed. The selected MAX AMPLITUDE voltage is displayed. This number reads 0.0 if a digital "0" has been applied. AC coupling is indicated by the letter A, DC coupling by the letter D, and the test signal by the letter T.

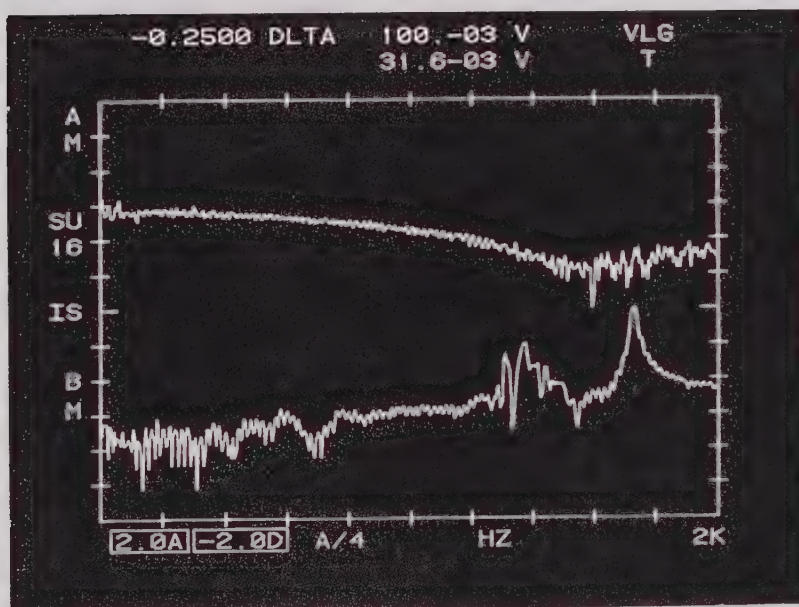


FIGURE 6B

SECTION 7

CAPTURE CONTROLS

7.0 CAPTURE CONTROL Group

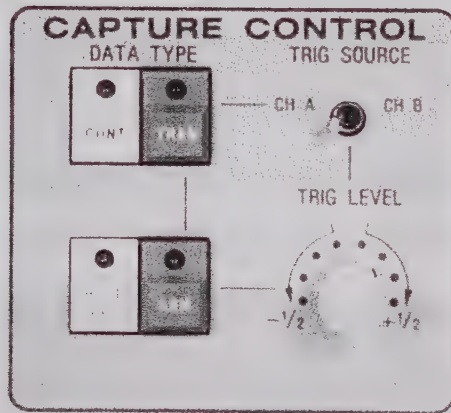


FIGURE 7A

Figure 7A illustrates the capture control group located in the lower central portion of the front panel. The DATA TYPE controls allow selection of processing of continuous or transient signals. When the CONT button is depressed, a Hanning squared, cosine⁴, window is applied to the data. When the TRAN button is depressed, the data is analyzed using a uniform window. Hence, the data may be weighted or unweighted.

Note that entering or exiting the transient mode of averaging causes the automatic selection of unweighted data type or weighted data type. The automatic selection may be overridden manually.

The instrument may be caused to hold its current input data window by depressing the manual HOLD button. When

this button is depressed, its associated LED lights. Depressing the button a second time causes the data to be released. This button permits freezing portions of the input signals for further examination.

Alternatively, the instrument may be programmed to automatically go into hold. This is accomplished by selecting either channel A or channel B to be the trigger source. The signal level which causes the hold state may be selected using the TRIG LEVEL rotary switch. This selector permits levels from $\pm 1/16$ to $\pm 1/2$ of the selected MAX AMPLITUDE to be chosen.

Depressing the ARM button, causing its LED to light, arms the analyzer to anticipate the transient capture conditions. When these conditions are met, the system automatically goes into a hold state.

Figure 7B illustrates the display annotation reflecting the status of the capture controls. The circled T indicates that the transient data type has been selected. Continuous data type is indicated with a C. When operating in correlation mode a special window is provided regardless of the settings of the data type controls. This window is uniform over the first half of the time window and zero over the second half of the time window. The correlation window is indicated by the annotation ZC for zeroed correlation

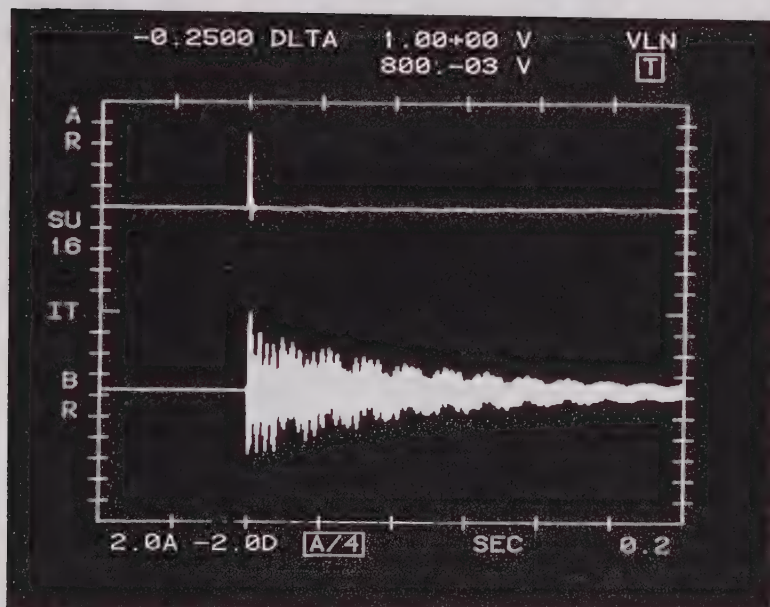


FIGURE 7B

window.

Annotation below the display indicates the status of the TRIG SOURCE and TRIG LEVEL controls. Absence of a sign is a positive trigger level. A minus sign is used for negative levels. The letter A or B indicates which channel is the trigger source. The suffix, / 4, indicates the trigger level is 1/4 of the selected maximum amplitude.

SECTION 8

AVERAGING CONTROL GROUP

8.0 AVERAGE Control Group

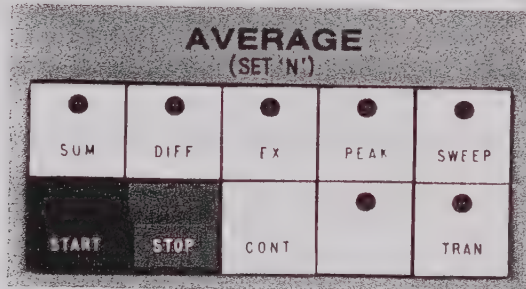


FIGURE 8A

Figure 8A illustrates the averaging control group.

One of nine averaging modes may be selected. These are:

1. SUM, Summation
2. DIFF, Difference
3. EX, Exponential
4. PEAK, Peak
5. SWEEP, Sweep
6. TRAN SUM, Transient Summation
7. TRAN DIFF, Transient Difference
8. TRAN EX, Transient Exponential
9. TRAN PEAK, Transient Peak

When operating in signal enhancement, the instrument performs ensemble averaging for channel A and B data in the time domain. When operating in the 2K channel A FFT mode the instrument performs ensemble averaging of the power spectra of data applied to channel A. When operating in either the 1K channel A-B FFT or the correlation modes, the instrument performs ensemble averaging of the power spectra for both channel A and channel B as well as ensemble averaging of the real and imaginary components of the cross spectrum between channels A and B. When operating in the probability mode, the instrument performs accumulation of occurrence and amplitude of the data applied to both channels A and B.

When summation averaging is selected, the averager section performs summation averaging over N preset spectra or time windows. The number N is entered through the calculation control group discussed in Section 16. In summation averaging, each constituent in the average is weighted equally. When averaged functions are displayed, their amplitude is continuously normalized based upon the number of

constituents currently averaged. Summation averaging may be conducted on statistically independent time windows, non-redundant data, or upon sequential time records that overlap by no more than 50% (50% redundancy). Averaging redundancy is determined by entry through the calculation control group.

Difference averaging is very similar to summation averaging except that each constituent is subtracted, rather than added, from the average. Normally, difference averaging is performed following a summation average. Difference averaging permits subtracting a noise background from experimental measurements. As implemented in the 660, difference averaging may be performed either before or after the summation average with the same effect.

Exponential averaging is a moving average in time. In this mode of averaging, the most recent information is weighted heavily while the oldest history is weighted lightly. The weighting function between these extremes is time exponential, hence the name. Exponential averaging is equivalent to placing a resistor-capacitor (RC) filter or leaky integrator on each point in the spectrum.

Peak averaging is not truly an average. It provides a one time statistic. In peak averaging, the largest event that occurs at any frequency or time position is stored in

the averager memory. Peak averaging provides the "worst case" spectrum or time record. When peak averaging is selected, every spectrum computed by the 660 is tested to see if the value within it has exceeded a previously stored value. This processing is, therefore, performed at maximum redundancy.

Sweep averaging is specifically designed for the analysis of systems excited by swept sine. Sweep averaging is summation averaging conducted at maximum redundancy. That is, summation averaging is performed at the maximum 660 spectrum computation rate, rather than waiting for the required redundancy conditions.

Transient averaging is a special mode of averaging optimized for the analysis of transient signals. When a transient averaging mode is entered, TRANS data type is selected automatically. Exiting the transient averaging mode automatically sets the data type to CONT (refer to Section 7). During transient averaging the instrument automatically re-arms itself after each transient acquisition. If an acquired transient caused an overload of the instrument's analog-to-digital converters, it is not averaged. The instrument only averages spectra or time histories resulting from transient inputs that satisfied the trigger conditions but did not overload the input of the instrument. This averaging mode is particularly useful when examining structures using impulsive techniques as discussed in the Application Notes. The transient mode is available when using summation,

difference, exponential or peak averaging.

An averaging process is initiated by depressing the START pushbutton. The LED on the START button remains lighted while averaging is being conducted. At the conclusion of the averaging period, this led turns off.

Depressing the START button erases any previously averaged data and starts the averaging count from one.

Normally, averaging is conducted until the preset averager N is reached. The process may be manually stopped or interrupted by depressing the STOP pushbutton. To resume the averaging process, depress the CONT, continue, pushbutton. Depressing the CONT pushbutton does not erase prior information nor does it reset the averaging counter. The CONT pushbutton may be used to average data in excess of the preset N without incurring any scaling errors.

Figure 8B illustrates CRT annotation describing the status of the averaging process. The present averaging conditions are specified by a 2 or 3 letter code for averaging mode directly above the preset averager N, i.e., SU 100 shown here. The averaging codes are:

1. SU for Summation
2. DF for Difference
3. EX for Exponential

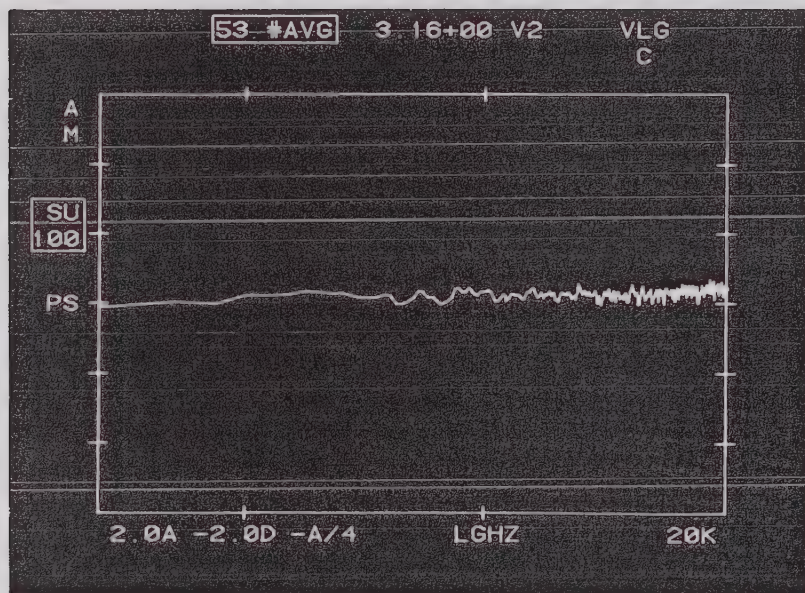


FIGURE 8B

4. PK for Peak
5. SW for Sweep
6. TSU for Transient Summation
7. TDF for Transient Difference
8. TEX for Transient Exponential
9. TPK for Transient Peak

Also, the calculation control group permits displaying the running averager count (RECALL AVG N) as the process proceeds. The annotation 53 # AVG, shown here indicates that 53 of the preset 100 averages have been acquired at this instant in time. Table 8-1 summarizes the system's averaging modes. Table 8-2 summarizes the mathematical operations performed in the various averaging modes.

In the "wake-up" state the averager is preset to summation averaging mode with N equal to 16.

TABLE 8-1

VALID AVERAGING MODES

OPERATING MODE AVG MODE	SIG ENH	CHA 2K	DUAL 1K	CORR	PROB
1. SUMMATION	X	X	X	X	X
2. DIFFERENCE	X	X	X	X	
3. EXPONENTIAL	X	X	X	X	
4. PEAK		X	X	X	
5. SWEEP		X	X	X	
6. TRANSIENT SUMMATION	X	X	X	X	X
7. TRANSIENT DIFFERENCE	X	X	X	X	
8. TRANSIENT EXPONENTIAL	X	X	X	X	
9. TRANSIENT PEAK		X	X	X	

TABLE 8-2

AVERAGING OPERATIONS

Type of Averaging	Operation Performed
Summation $\left\{ \begin{array}{l} \text{SU} \\ \text{TSU} \\ \text{SWEEP} \end{array} \right\}$	$G_{k+1} = G_k + S_{k+1} \quad 0 \leq k \leq N$ $0 \leq k \leq \infty \text{ for sweep}$ $P_{i(k+1)} = \begin{array}{l} P_{i(k)} \text{ for } A_{i(k+1)}(t) \neq v_i \\ P_{i(k)+1} \text{ for } A_{i(k+1)}(t) = v_i \end{array}$
Difference $\left\{ \begin{array}{l} \text{DF} \\ \text{TDF} \end{array} \right\}$	$G_{k+1} = G_k - S_{k+1} \quad 0 \leq k \leq N$
Exponential $\left\{ \begin{array}{l} \text{EX} \\ \text{TEX} \end{array} \right\}$	$G_{k+1} = \frac{S_{k+1} - G_k}{2^{\exp(N^*)}} + G_k \quad 0 \leq k \leq \infty$ $N^* = \text{Integer}(\log_2 N)$
Peak $\left\{ \begin{array}{l} \text{PK} \\ \text{TPK} \end{array} \right\}$	$G_{k+1} = \max \left\{ S_{i(k+1)}, G_{ik} \right\} \text{ for all } i$ $0 \leq k \leq N$

Notation:

- P = Probability value
 A(t) = Input time waveform
 G = Current averaged spectrum or spectra
 S = Instantaneous spectrum
 k = Number of averages completed
 N = Number of averages set via Calculation Control Keyboard. Wake up value = 16
 i = Particular cell in spectrum mode or bin in probability mode
 v_i = Voltage range associated with bin i

SECTION 9

FUNCTION CONTROL GROUP

9.0 FUNCTION Control Group

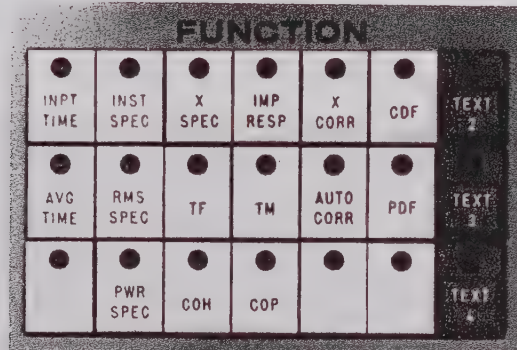


FIGURE 9A

Figure 9A illustrates the function control group. Depressing a button in this group causes the display of a selected function. If the selected function is not available in the selected operating mode, the error message FUNCTION N/A, for function not available, will be seen in the entry/recall field. Functions available by mode are listed in Table 4-1.

All functions with the exception of INPT TIME, input time histories, and INST SPEC, instantaneous spectra, require averaging for their computation. Hence, the averaging process must be started before meaningful displays of most

functions will be obtained. Any function may be viewed while the averaging is in process.

The selected function is denoted on the CRT display by a function label. In Figure 9B, the annotation PS indicates that a power spectrum is being displayed.

Table 9-1 summarizes the available functions, their front panel abbreviations in the function control group, their CRT function labels, and modifications to these labels indicating the effects of controls described in Sections 12 and 15. Table 9-2 gives the mathematical definitions of the available functions.

In the "wake up" state, instantaneous spectrum is the selected function.

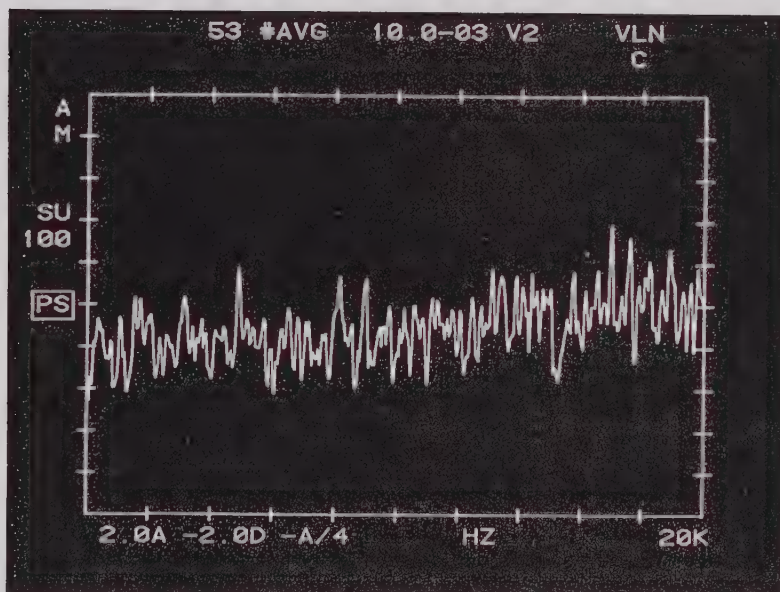


FIGURE 9B

FUNCTION	PANEL ABBREVIATION	CRT LABEL	MODIFIED LABEL*	AVERAGING REQUIRED	DATA TYPE
INPUT TIME HISTORY	INPUT TIME	IT	-	NO	REAL
AVERAGED TIME HISTORY	AVG TIME	AT	-	YES	REAL
AVERAGED TIME SPECTRUM	INST SPEC	ATS	ATD	YES	COMPLEX
IMPULSE RESPONSE	IMP RESP	IR	EIR	YES	REAL
INSTANT SPECTRUM	INST SPEC	IS	ISD	NO	COMPLEX
RMS SPECTRUM	RMS SPEC	RS	RSD	YES	MAGNITUDE
POWER SPECTRUM	PWR SPC	PS	PSD	YES	MAGNITUDE
COHERENT OUTPUT POWER SPECTRUM	COP	CP	CPD	YES	MAGNITUDE
CROSS SPECTRUM	X SPEC	CS	CSD	YES	COMPLEX
TRANSFER FUNCTION	TF	TF	ETF	YES	COMPLEX
TRANSMISSIBILITY FUNCTION	TM	TM	ETM	YES	MAGNITUDE
COHERENCE FUNCTION	COH	COH	-	YES	REAL
AUTO CORRELATION FUNCTION	AUTO CORR	ACF	-	YES	REAL
CROSS CORRELATION FUNCTION	X CORR	CCF	-	YES	REAL
PROBABILITY DENSITY FUNCTION	PDF	PDF	-	YES	REAL
CUMULATIVE DISTRIBUTION FUNCTION	CDF	CDF	-	YES	REAL

* "E" Prefix Denotes Equalization, i.e. Equalized Impulse Response = EIR
 "D" Suffix Denotes Density (per Hz) Normalization, i.e. Power Spectral Density = PSD

TABLE 9-1

FUNCTION LABELS

TABLE 9-2 DEFINITIONS OF FUNCTIONS

DISPLAY SELECT	FUNCTION COMPUTED	DESCRIPTION
Time (Δ) (Inpt. Time - 1T)	$A(t)$	Digital time history of input signal. (Display shows actual data processed)
Instant FFT (Δ) (Inst. Spec. - IS)	$S_A = \mathcal{F}\{A(t)\}$ $= S_A \cos(\phi_A) + j S_A \sin(\phi_A)$	Complex spectrum of time history, $A(t)$. Magnitude $ S_A $ defines instantaneous spectral content. Phase angle, ϕ_A , describes <i>relative phasing</i> of periodic harmonic components. Absolute angles are only meaningful if analysis window is synchronized to periodic harmonic data.
LIN	$ S_A $	
LOG	$20 \log_{10} S_A $	
PHASE	ϕ_A	
REAL	$ S_A \cos \phi_A$	
IMAG	$ S_A \sin \phi_A$	
Aver. Spec. (Δ) (Pwr. Spec. - PS)	$G_{AA} = \overline{S_A \cdot S_A^*}$ $= \overline{S_A^2}$	Ensemble average of squared spectrum magnitude (formed by multiplying complex spectrum by its conjugate). A real (rather than complex) spectrum, defining <i>average power</i> at each frequency.
LIN	G_{AA}	
LOG	$10 \log_{10} G_{AA}$	
(RMS Spec. - RS)	$\sqrt{G_{AA}}$	
Aver Cross Spec (X Spec. - CS)	$G_{AB} = \overline{S_B \cdot S_A^*}$ $= S_A S_B \cos(\phi_B - \phi_A) + j S_A S_B \sin(\phi_B - \phi_A)$	Ensemble averaged complex product of spectrum, S_B , with conjugated spectrum, S_A^* . Indicates those frequencies where <i>both</i> $A(t)$ and $B(t)$ have content. Phase angles indicate average phase <i>difference</i> between signals at each frequency.
LIN MAG	$ G_{AB} $	
LOG MAG	$10 \log_{10} G_{AB} $	
PHASE	$\phi_B - \phi_A$	
REAL	$ G_{AB} \cos(\phi_B - \phi_A)$	
IMAG	$ G_{AB} \sin(\phi_B - \phi_A)$	
Transfer Function (TF)	$H_{AB} = \frac{G_{AB}}{G_{AA}} = \frac{S_B \cdot S_A^*}{S_A \cdot S_A^*}$ $= \frac{ G_{AB} \cos(\phi_B - \phi_A) + j G_{AB} \sin(\phi_B - \phi_A)}{ G_{AA} }$	Complex ratio of cross spectrum, G_{AB} , to input power spectrum, G_{AA} , defines the gain and phase lag introduced by a transmission system <i>excited</i> by $A(t)$ and <i>responding</i> with $B(t)$.
LIN MAG	$ H_{AB} $	
LOG MAG	$20 \log_{10} H_{AB} $	
PHASE	$\phi_B - \phi_A$	
REAL	$ H_{AB} \cos(\phi_B - \phi_A)$	
IMAG	$ H_{AB} \sin(\phi_B - \phi_A)$	
Transmissibility (TM)	$H'_{AB} = \frac{G_{BB}}{G_{AA}} = \frac{S_B \cdot S_B^*}{S_A \cdot S_A^*}$	Real ratio of output power spectrum to input power spectrum.
LIN	$ H'_{AB} $	
LOG	$20 \log_{10} H'_{AB} $	
Impulse Response (Imp. Resp. - IR)	$IR = \mathcal{F}^{-1}\{H_{AB}\}$	Impulse response of the system assuming input $A(t)$ and response $B(t)$.

DEFINITIONS OF FUNCTIONS

DISPLAY SELECT	FUNCTION COMPUTED	DESCRIPTION
Coherent Output Power (COP) LOG	$\text{COP} = \frac{G_{AB} \cdot G_{AB}^*}{G_{AA}}$ $= \gamma_{AB}^2 G_{BB}$ $10 \text{ LOG}_{10} \text{ COP}$	Coherent output power (COP) spectrum indicates power in signal, B(t), that is coherent with signal, A(t). Total power spectrum G_{BB} , indicates entire content of B(t) while COP indicates only that portion caused by A(t) thru a linear process. When B(t) is caused by unrelated multiple inputs, COP indicates only that portion due to single input, A(t)
Coherence (COH)	$\gamma_{AB}^2 = \frac{G_{AB} \cdot G_{AB}^*}{G_{AA} \cdot G_{BB}}$ $= \frac{ G_{AB} ^2}{G_{AA} \cdot G_{BB}}$	Real Spectrum "power squared" ratio indicates <i>linear cause/effect</i> relationship between A(t) and B(t). Linear transmission system excited <i>only</i> by A(t) yields $\gamma_{AB}^2 = 1$ at all frequencies. Non-linearities or inputs in addition to A(t) produce γ_{AB}^2 between "0" and "1".
Auto-Correlation Function (Δ) (Auto Corr. - ACF)	$R_{AA}(\tau) = \mathcal{F}^{-1}\{G_{AA}\}$ $= \frac{1}{P} \int_0^P A(t) \cdot A(t+\tau) dt$	Time domain statistic comparing <i>similarity</i> of A(t) to replicates of <i>itself</i> , delayed by time, τ . At $\tau = 0$, R_{AA} = mean square of A(t). As $\tau \rightarrow \infty$, R_{AA} approaches square of mean value. Oscillations in R_{AA} indicate <i>bandwidth</i> and <i>periodicity</i> of A(t).
Cross-Correlation Function (X Corr. - CCF)	$R_{AB}(\tau) = \mathcal{F}^{-1}\{G_{AB}\}$ $= \frac{1}{P} \int_0^P A(t) B(t+\tau) dt$	Time statistic comparing <i>similarity</i> of A(t) and B(t). Value of τ that maximizes R_{AB} indicates <i>time lag</i> between signals. Maximum value of R_{AB} divided by square root of $[R_{AA}(0)] [R_{BB}(0)]$ yields correlation coefficient (equal to 1 for identical signals, 0 for unrelated signals).
Signal Enhancement (Δ) (Avg. Time - AT)	$\bar{A}(t)$	Ensemble averaged time histories computed at each time point across a series of instantaneous time histories, each triggered from a common condition. Used to extract mean value time history.
Linear Spectrum (Δ) (Inst. Spec. - IS) LIN MAG LOG MAG PHASE REAL IMAG	$S_{\bar{A}} = \mathcal{F}\{A(t)\}$ $= S_{\bar{A}} \cos(\phi_{\bar{A}}) + j S_{\bar{A}} \sin(\phi_{\bar{A}})$ $ S_{\bar{A}} $ $20 \text{ LOG}_{10} S_{\bar{A}} $ $\phi_{\bar{A}}$ $ S_{\bar{A}} \cos \phi_{\bar{A}}$ $ S_{\bar{A}} \sin \phi_{\bar{A}}$	Complex spectrum of the average time data. Magnitude $ S_{\bar{A}} $ defines the spectral content. Phase angle $\phi_{\bar{A}}$ describes relative phasing of periodic harmonic components. Absolute angles are only meaningful if analysis windows were synchronized to periodic harmonic data.
Probability Density Function (PDF)	$q(x) = \frac{d[Q(x)]}{dx} \text{ such that}$ $\int_a^b q(x) dx = P \left\{ a < A \leq b \right\}$	Statistic defining most probable amplitude of A(t).
Cumulative Distribution Function (CDF)	$Q(x) = P \left\{ A \leq x \right\} = \int_0^x q(x) dx$	Statistic defining probability that time signal A(t) has instantaneous amplitude of x or less.

Definition of Symbols

A(t)	-	Input time function on Channel A
B(t)	-	Input time function on Channel B
S	=	Magnitude of instant FFT = $\sqrt{S_{\text{REAL}}^2 + S_{\text{IMAG}}^2}$
ϕ	=	Phase angle of instant FFT = $\tan^{-1} \frac{S_{\text{IMAG}}}{S_{\text{REAL}}}$
j	=	$\sqrt{-1}$

S^*	=	Complex conjugate of $S = S_{\text{REAL}} - j S_{\text{IMAG}}$
(overbar)	=	Ensemble average
t	=	Time
τ	=	Artificially introduced time delay
$\mathcal{F}\{ \}$	=	Direct Fourier Transformation
$\mathcal{F}^{-1}\{ \}$	=	Inverse Fourier Transform

(Δ) Similar for Channel B

DISPLAY (CHANNEL/FORMAT) CONTROLS

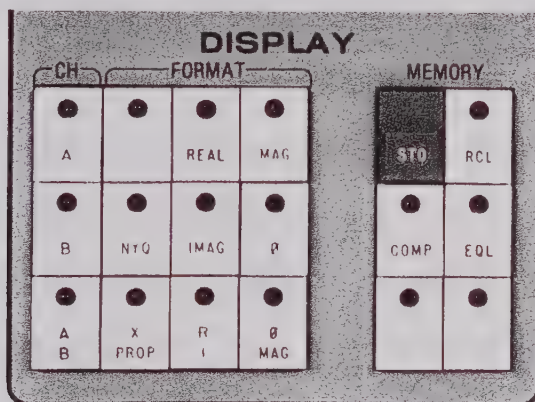
10. DISPLAY Controls

FIGURE 10A

Figure 10A illustrates the display control group. Controls are provided to select a channel (CH) and a format (FORMAT).

The CH pushbuttons select the channel from which the selected function will be displayed. For single channel functions only CH A selection is valid. For dual channel functions, choices of channel A or channel B or channels A & B are provided. The available selections are listed in Table 10-1.

The FORMAT pushbuttons determine how the selected single channel or cross property function will be displayed.

The function to be displayed may have one of three format types, namely: complex, magnitude or real. The format types are specified in Table 9-1.

A single complex function contains two pieces of information. In rectangular coordinates these are called the real and imaginary components, while in polar coordinates, they are called the magnitude and phase components.

When a complex function is displayed, its real, imaginary, or both its real and imaginary, RI, may be displayed. Alternatively, the imaginary component may be cross plotted against the real component by selecting a Nyquist display format. Additionally, the same information may be plotted in polar coordinates. Choices of magnitude, phase, or both phase and magnitude may be selected.

For data whose format type is either magnitude or real only those formats are valid, respectively. Refer to Table 9-1 for further clarification.

When a function of either real or magnitude type is selected, the instrument automatically selects the appropriate format. When a complex function is selected, the instrument automatically selects the last manual selection for format.

The 660 has provisions to display one or two traces at a time. This permits the simultaneous display of two real or two magnitude functions or the entire display of a single complex function. Additionally, a single attribute, i.e. magnitude, phase, real, or imaginary, of two complex functions, one from channel A and one from channel B, may be displayed simultaneously. Attempting to display more than two traces or selecting an improper format may result in an entry/recall field error message. These messages are summarized in Appendix A.

The Nyquist display format button normally is used to cross plot a complex function's real and imaginary components. This format may also be selected to cross plot two time histories, either instantaneous or averaged.

Figures 10B, 10C, and 10D illustrate the CRT annotation reflecting the status of the display controls. In Figure 10B, two instantaneous spectra are displayed. The upper trace is the data from channel A while the lower trace is the data from channel B. Both displays are of spectrum magnitude. In Figure 10C a transfer function (cross property function) is displayed. The upper trace is the phase spectrum while the lower trace is the magnitude (ratio) spectrum. In Figure 10D the real (horizontal) and imaginary (vertical)

TABLE 10-1
AVAILABLE DISPLAY FORMATS

	INPT TIME	AVG TIME	IMP RESP	INST SPEC	RMS SPEC	PWR SPEC	COP	CROSS SPEC	TF	TM	COH	AUTO CORR	CROSS CORR	PDF	CDF
A REAL	x	x		x								x		x	x
A IMAG				x											
A R/I				x											
A MAG				x	x	x									
A PHASE				x											
A PH/MAG				x											
A NYQ				x											
B REAL	x	x		*								x		x	x
B IMAG				*											
B R/I				*											
B MAG				*	*	*									
B PHASE				*											
B PH/MAG				*											
B NYQ				*											
AB REAL	x	x		*								x		x	x
AB IMAG				*											
AB R/I															
AB MAG				*	*	*									
AB PHASE				*											
AB PH/MAG															
AB NYQ	x	x													
XP REAL			x					x	x		x		x		
XP IMAG								x	x						
XP R/I								x	x						
XP MAG							x	x	x	x					
XP PHASE								x	x						
XP PH/MAG								x	x						
XP NYQ								x	x						

* Not Valid in 2K
x Valid Formats
XP Cross Power Functions

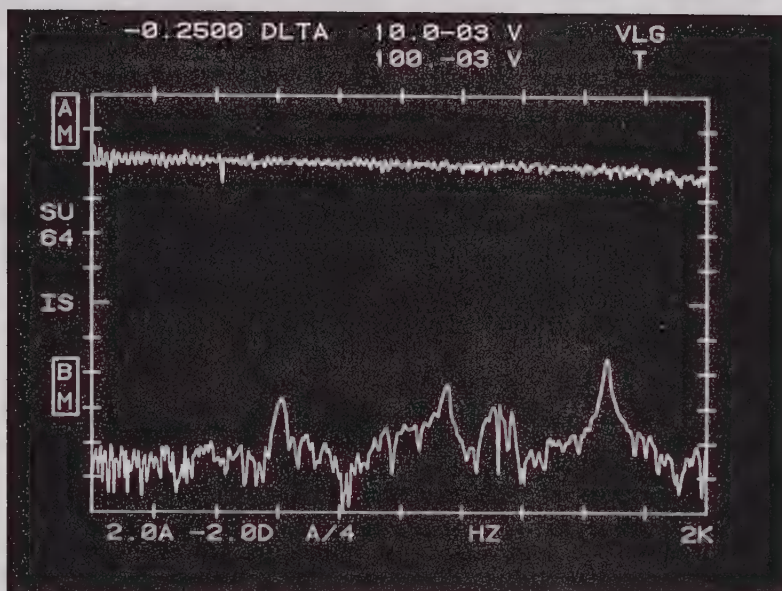


FIGURE 10B

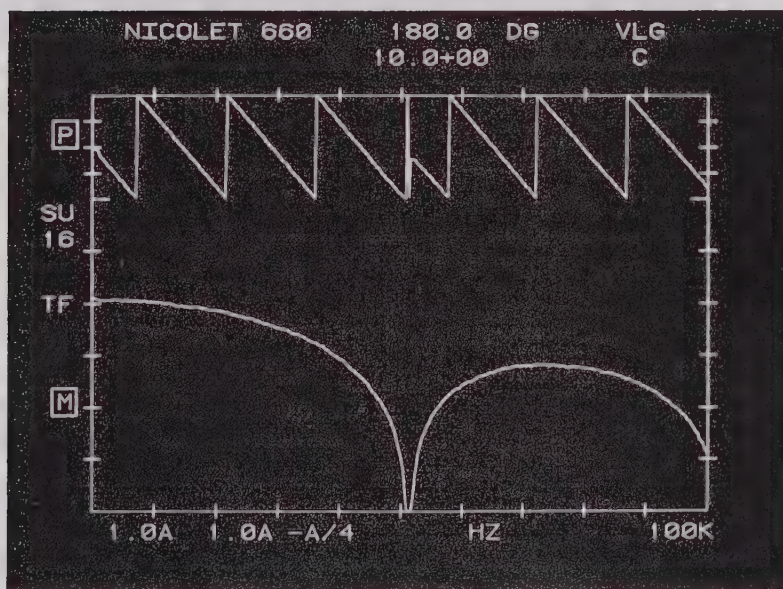


FIGURE 10C

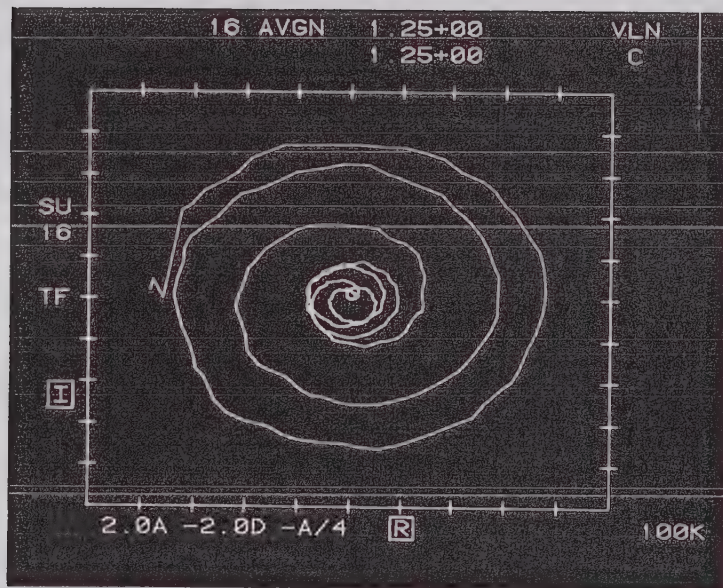


FIGURE 10D

components of a transfer function are cross plotted in Nyquist format.

In the "wake up" state, channel is set to A-B while format is set to magnitude.

DISPLAY SCALES CONTROLS

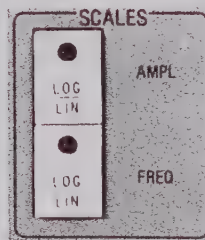
11. Display SCALES Controls

FIGURE 11A

Figure 11A illustrates the SCALES controls. These pushbuttons allow alternate selection of linear or logarithmic horizontal and vertical axes for the CRT display. When logarithmic axes are selected, the LEDs are illuminated. When linear axes are selected, the LEDs are off.

The amplitude scales control only affects functions whose data type is complex or magnitude. Real functions are always displayed with linear amplitude.

The lower frequency scales control affects functions of frequency. Time functions are always presented with a linear horizontal axis.

Both the display form and CRT annotation reflect the status of the SCALES controls. Figure 11B illustrates a power spectrum presented with linear amplitude vs. linear frequency. The vertical axis label, VLN, indicates that the vertical axis of this display is linear. When linear displays are drawn, nine tick marks (10% apart) are always drawn for each data trace. The horizontal axis label Hz indicates that the horizontal axis is linear. Again, tick marks are 10% apart.

Figure 11C illustrates the same data presented with logarithmic vertical and horizontal axes. The vertical axis label, VLG, indicates that the vertical axis is logarithmic. The tick marks on logarithmic vertical displays are always 10 dB apart. The display range, or number of 10 dB intervals, may be specified through the calculation control group. The horizontal axis label, LGHz, indicates that the horizontal axis is logarithmic. The tick marks are one decade apart.

In the "wake up" state the amplitude scale is set to logarithmic while the frequency scale is set to linear. The display range is set to 60 dB.

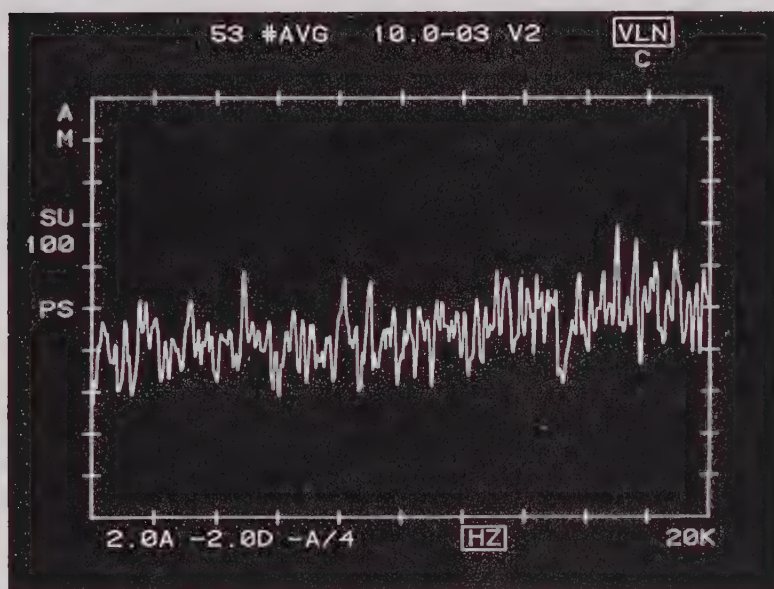


FIGURE 11B

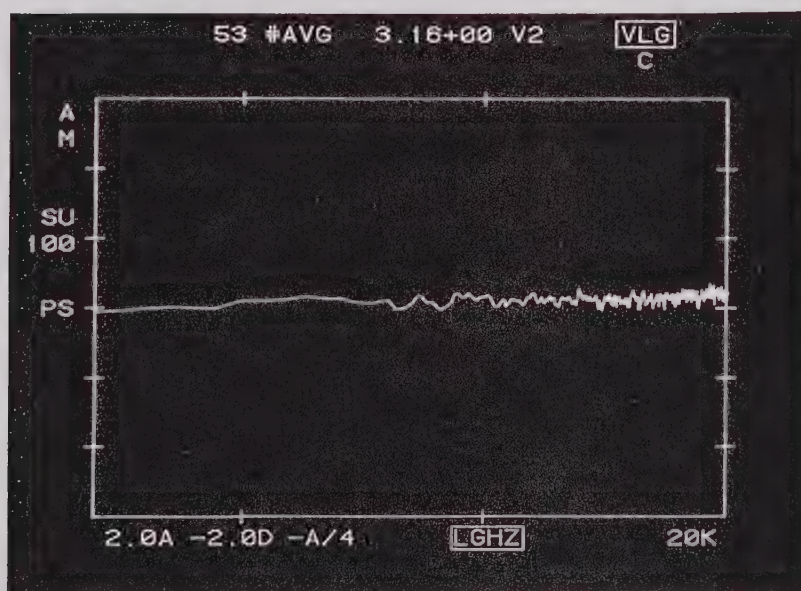


FIGURE 11C

DISPLAY GAIN AND UNITS CONTROLS

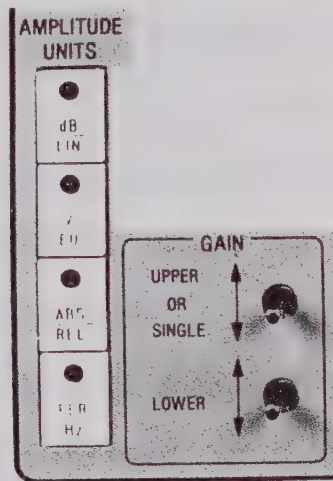
12. GAIN and AMPLITUDE UNITS

FIGURE 12A

Figure 12A illustrates the controls that select amplitude units and display gain. The pushbuttons grouped under the heading AMPLITUDE UNITS determine not only the cursor readings but the scaling of the display traces. These four pushbuttons perform alternate action selection.

The ABS/REL switch determines whether the vertical units of the display and cursor readout will be in absolute or relative units. Absolute units may be either voltages as directly measured by the instrument, or engineering units calculated from the voltages readings and engineering unit

scale constants. The engineering unit scale constants are entered through the calculation control group. Relative units are ratiometric measurements between two data traces or between two points on a single data trace. Relative measurements are made from a reference value entered through the calculation control group.

The V/EU switch determines whether the absolute units will be volts or engineering units. Changing the status of either V/EU or the ABS/REL pushbuttons will affect the vertical scaling of the data, depending upon the engineering unit scale constants and relative reference entered, and may require changing the gain of the display.

The dB/LIN switch determines whether the display full scales and the amplitude-at-cursor readouts will be in linear units (volts, engineering units, or relative) or in dB (with respect to one linear unit). This selection is independent of the amplitude scales selection.

The alternate action PER Hz switch controls the application of density normalization to displayed spectra. Depressing the PER Hz pushbutton normalizes the amplitude of a displayed spectrum to 1 Hz bandwidth. Density normalization (per Hz) may be applied to five frequency functions as specified in Table 9-1. When the PER Hz pushbutton is depressed,

the function label is modified by the addition of the suffix D (for density normalization).

The GAIN cursors determine the height of the displayed traces. When a single trace is displayed, the UPPER gain cursor determines the size of the display. When two traces are displayed simultaneously, the UPPER gain cursor determines the height of the upper trace while the LOWER cursor determines the height of the lower trace.

Three exceptions should be noted:

1. When the coherence and cumulative distribution functions are displayed, the gain cursors are inactive. Because these functions are always bounded between zero and one, there is no need for variable display gain. Hence, the bottom of the display is always zero and the top of the display is equal to one when the coherence and cumulative distribution functions are selected.
2. Phase data is always displayed between $\pm 180^\circ$. 0° is always the center of a phase display. The GAIN cursors do not affect a phase display.

3. When magnitude and phase format is displayed, the UPPER cursor determines the gain of the magnitude display. The LOWER gain is inactive.

The GAIN cursors actually determine the full scale value of the CRT display. The 660 automatically scales the displayed data so that the full scale is a nice number. When the AMPL SCALES button is in the linear position, pressing a GAIN cursor downward steps the full scale through the sequence 1, 1.25, 1.5, 2, 2.5, 3, 4, 5, 6, or 8 times 10 to an integer exponent(± 39). Raising the cursor steps the full scale through the same sequence in the opposite direction.

Direct keyboard entry of a desired display full scale may be made through the calculation control keyboard. Enter the full scale value (in linear units if the dB/LIN switch is in LIN, in dB if the dB/LIN switch is in dB), SET/STORE, followed by activation of the GAIN switch for the appropriate display. UPPER OR SINGLE sets the gain for the upper display if two displays are on screen or the displayed data if only a single display is on screen. LOWER sets the gain for the lower display if two displays are on screen. The gain setting for a single display always corresponds to the gain setting for the upper of two displays.

When the AMPL SCALES selector is in the logarithmic position, moving the GAIN cursor causes the display full scale to change in 10 dB steps. If the AMPLITUDE UNITS dB/LIN button is in the linear position, the full scale will be either 3.16 or 10 multiplied by 10 to an integer power. With this selector in the dB position, the full scale will be an integer power of 10 dB with reference to one physical unit of the displayed measurement.

The CRT display annotation reflects the status of the AMPLITUDE UNITS and GAINS controls as illustrated in Figures 12B, 12c, 12d, and 12e. In Figure 12B a power spectrum is displayed. The full scale amplitude of the display in volts² is displayed. The label V2 indicates that volts² are being displayed. If an INST or RMS spectrum had been displayed, the label V for volts would have appeared.

In Figure 12C the V/EU selector has been changed from the volts to the engineering unit position. Additionally, the volt per engineering unit scale constants have been recalled to the entry recall field. The physical readout is now in engineering units² as indicated by the E2 label. Readout in linear engineering units is denoted by the symbol E. When using relative measurements rather than absolute, the symbols R and R2 are used. In Figure 12D a power spectrum is

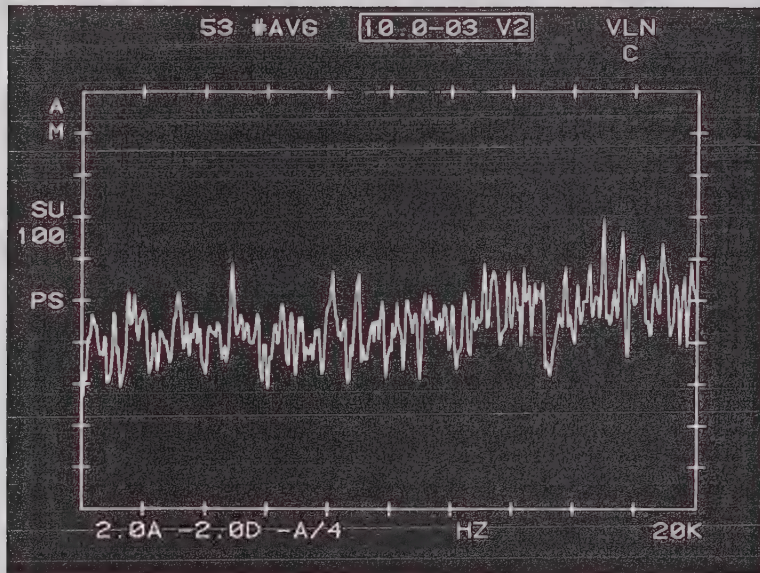


FIGURE 12B

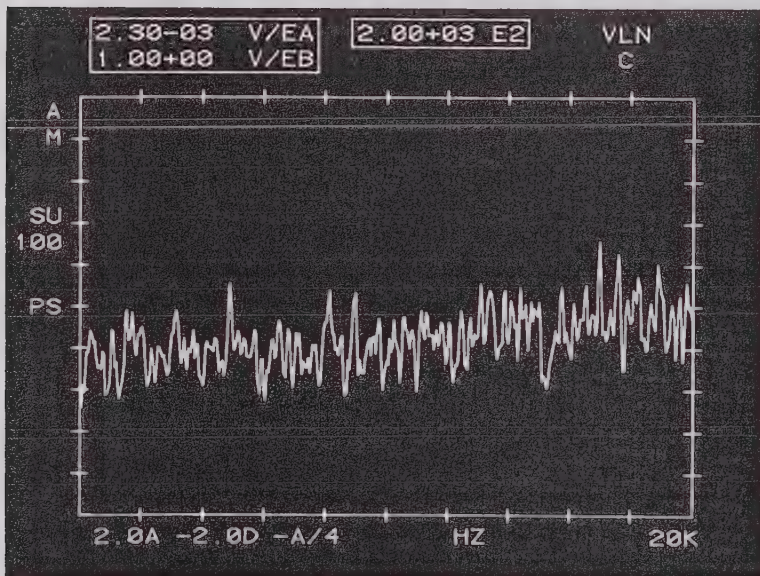


FIGURE 12C

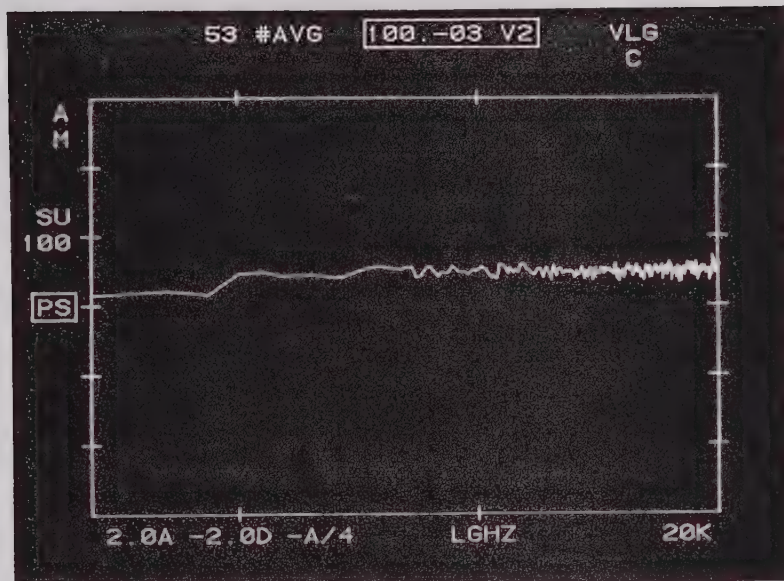


FIGURE 12D

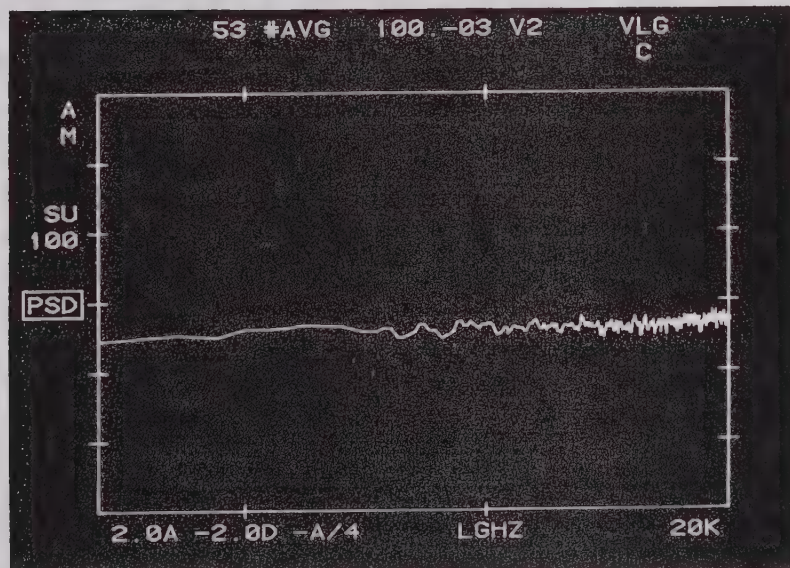


FIGURE 12E

displayed with logarithmic amplitude. Note that the vertical units are volts² (V2) and that the function label PS indicates a power spectrum is being displayed.

Figure 12E shows the same power spectrum after the PER Hz pushbutton was depressed. Note that the function label has been changed from PS to PSD indicating that density normalization has been applied. The units of the full scale are now volts²/Hz.

Any combination of the pushbuttons under the AMPLITUDE UNITS label is valid. Note that the units of amplitude measure are 0 to Peak for functions in the time or amplitude domains and RMS for functions in the frequency domain.

In the "wake up" state the AMPLITUDE UNITS pushbuttons are initialized to linear, volts, absolute and per Hz off. Additionally, the GAIN controls are initialized to match the settings of the maximum amplitude controls.

SECTION 13

CURSOR CONTROLS

13. CURSOR POSITION, CURSOR TYPE, and FREQ READS

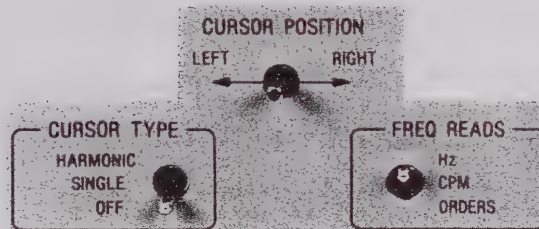


FIGURE 13A

Figure 13A illustrates the cursor control group. The CURSOR TYPE switch permits turning the cursor off, providing a single cursor or a harmonic cursor. Selecting HARMONIC cursor type provides a single line intersecting the data with additional intensified dots at harmonics of the cursor position.

When the cursor is turned on, the CURSOR POSITION switch permits positioning the cursor left or right. Touching this control once advances the cursor one location. Holding this control to the left or right causes the cursor to slew. Alternatively, the cursor position may be explicitly selected

through the calculation control group.

The FREQ READS selector affects the readout of horizontal units. Normally, (when the FREQ/ORDERS switch is in the FREQUENCY RANGE control is set to FREQ), horizontal readout is in Hz for frequency functions, is in seconds for time functions, and is in voltage or engineering units for amplitude functions. The FREQ reads switch only affects functions of frequency or time. In the Hz position, units of Hz and seconds are used. In the CPM position, units of cycles per minute are displayed in frequency, and fractions of time windows (specified by the frequency range) are displayed in time. In the ORDERS position, orders (normalized frequency) are used for frequency and units of cycles (inverse orders) are used for time. The order reference is established through the calculation control group. See Table 13-1.

When the FREQ/ORDERS switch is in the ORDERS position, the sampling frequency for input time conversion is supplied by user. Since the 660 Analyzer does not know the relationship of this sampling frequency to the input time signal, it is not possible to properly annotate time or frequency in terms of Hz and CPM but rather must annotate data in terms of samples or orders (that is frequency ratio). The readings obtained when the FREQ/ORDERS switch is in the ORDERS position is shown in Table 13-2.

Figure 13B illustrates a CRT display with the cursor turned on. The cursor takes the form of a vertical line intersecting the data trace or traces. The horizontal position of the cursor is read out directly below the entry recall field.

TABLE 13-1

HORIZONTAL READOUT AT CURSOR
FREQ/ORDERS SWITCH SET TO FREQ

DOMAIN OF DISPLAYED FUNCTION			
FREQUENCY READS SETTING	TIME	FREQUENCY	AMPLITUDE (PROBABILITY)
HZ	SECONDS	HZ	VOLT OR EU
CPM	FS	CPM	VOLT OR EU
ORDERS	CYC	ORD	VOLT OR EU

HZ = Hertz (Cycles/Second)
 CPM = Cycle/Minute
 ORD = Order (Frequency Ratio)
 FS = Fraction of Full Scale
 (Frequency Range or Time Window)
 CYC = Cycles (Order ⁻¹)
 # = Point or Cell Number

TABLE 13-2

HORIZONTAL READOUT AT CURSOR
FREQ/ORDERS SWITCH SET TO ORDERS

DOMAIN OF DISPLAYED FUNCTION			
FREQUENCY READS SETTING	TIME	FREQUENCY	AMPLITUDE (PROBABILITY)
HZ	#	#	VOLT OR EU
CPM	FS	FS	VOLT OR EU
ORDERS	CYC	ORD	VOLT OR EU

HZ = Hertz (Cycles/Second)
 CPM = Cycle/Minute
 ORD = Order (Frequency Ratio)
 FS = Fraction of Full Scale
 (Frequency Range or Time Window)
 CYC = Cycles (Order ⁻¹)
 # = Point or Cell Number

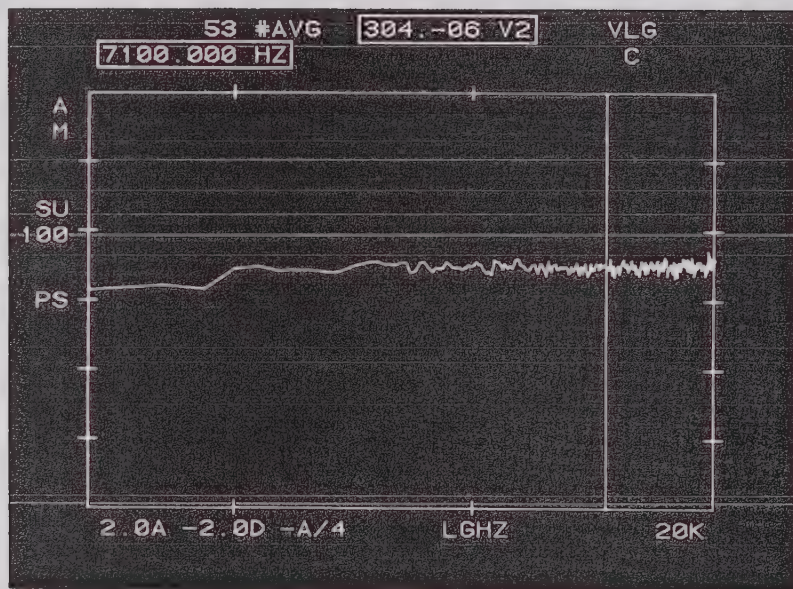


FIGURE 13B

In this example, the frequency readout is presented in Hz.

When the cursor is turned on, the amplitude at its location replaces the full scale annotation. Comparing Figure 13B and 12D shows this replacement. The readout units for full scale and cursor amplitude are consistent.

The "wake up" state uses the positions of the CURSOR TYPE, FREQ READS, OR CURSOR POSITION controls.

The cursor may be explicitly set by either of two methods:

Display Cell Number:

Enter the desired cursor cell number (1 to 400 for 400 point frequency displays, 1 to 800 for 800 point frequency displays, 0 to 2047 for 2048 point time displays, 1 to 127 for amplitude displays), followed by the decimal point, SET/STORE, and the CUR LOC key. This sequence causes the immediate movement of the cursor from its current position to the specified cell.

Annotated Units:

Enter the desired cursor horizontal location in the currently annotated units (i.e. Hz, CPM, etc.), followed by the SET/STORE and a left or right movement of the CURSOR POSITION switch. This sequence causes the immediate movement of the cursor from its current position to the position nearest the specified location.

The number of data points displayed on the CRT varies with the operating mode. In the 2K FFT mode 2048 time points can be displayed where as only 128 points are displayed in the probability mode. Normally, if the cursor were to be moved at a constant number of data points per second, it would take much longer to move from one end of the display to the other in the 2K mode than it would in the probability mode. In order to have

the slew rate fairly constant independent of display, the cursor is stepped more than one cell location depending on the display. These larger step sizes occur only during sweeping. Single stepping of the cursor always is one data point per step.

TABLE 13-3

CURSOR LARGER STEP SIZE BY DISPLAY TYPE

<u>Display</u>	<u>Cells on Display/128</u>	<u>Larger Step Size (Cells)</u>
Time Display (2K FFT Mode)	1024 2048	8 16
Frequency Display (2K FFT Mode)	400 800	3 6
Probability Display	128	1

The larger step size provides the user with a constant cursor range speed despite the amount of data on display. This larger step is 1/128 of the data cells on display and the above table gives the exact amount in each case.

SECTION 14

OUTPUT TYPE CONTROLS

14. OUTPUT TYPE



FIGURE 14

Figure 14 illustrates the OUTPUT TYPE controls. These controls specify the target for data output by the 660. Output targets include analog and digital devices.

Depressing the CRT ONLY pushbutton cancels all other forms of output from the instrument. CRT ONLY is the default status of the instrument. Unless another pushbutton in the output type group is depressed, output of the instrument is to the internal CRT only.

Depressing the AUX pushbutton causes digital or analog output to be channeled to an auxiliary device. The nature of the

transmission is specified through the DEF AUX key in the calculation control group. After the AUX key is depressed and its LED is illuminated, depressing the PLOT key causes digital output to the optional Model 134A Digital Plotter, or to the optional Model 136A Digital Plotting Adapter. With alternative entries to the DEF AUX, depressing this pushbutton can cause analog output equivalent to the current cursor to appear on the analog plotter terminals (rear panel) or data transmission through the RS232, IEEE488, or high speed parallel interfaces. The 80 DEF AUX series provides automatic pagination for use with the Model 136A Digital Plotting Adapter. The second digit of the series indicates the number of pages (8 1/2 x 11) the paper is to be advanced after each plot (e.g. 81 causes the 136A to position to the next page, ready for the next plot.). Details of the define auxiliary entries are contained in Section 19, Digital Interfaces. The LED on the AUX pushbutton remains lit for the duration of auxiliary data transmission. The transmission may be terminated manually by pressing the CRT ONLY pushbutton.

The PLOT CAL pushbutton is used in conjunction with an optional analog X-Y plotter and the optional 136A Digital Plotting Adapter. The first time this pushbutton is depressed, an output voltage is applied to the horizontal and vertical plotter

outputs corresponding to the lower lefthand corner of the display. The second time this pushbutton is depressed, the voltage at those terminals is changed to correspond with the upper righthand corner of the display. The third time this pushbutton is depressed, the PLOT CAL mode is exited.

When a two trace display is drawn, depressing the PLOT CAL pushbutton steps the voltages on the horizontal and vertical plotter outputs through a sequence corresponding to:

1. Lower lefthand corner of upper trace
2. Upper righthand corner of upper trace
3. Lower lefthand corner of lower trace
4. Upper righthand corner of lower trace
5. Exit PLOT CAL mode

The PLOT CAL mode is also exited if any of the remaining OUTPUT TYPE pushbuttons is depressed. If the AUX key has been depressed and its LED is illuminated, depressing the PLOT CAL pushbutton causes the output of the graticule corners over the RS232 or IEEE-488 interface, depending on the setting of the $\emptyset$ series DEFine AUX (see Figure 19-3). This feature allows the user to place the plotted graticules at specific locations on the plotter page. Refer to the 136A Plotter Manual for a further description of this sequence.

Depressing the PLOT pushbutton causes analog outputs necessary to draw the data of the screen image on an analog plotter to appear on the rear panel vertical and horizontal plotter outputs. Analog plotter output consists of data traces only, no graticule or annotation information is output.

When a plot is initiated by depressing the PLOT pushbutton, the CRT image remains unchanged. A single intensified dot is seen to scan across the CRT image, indicating the position of the analog plotter's pen. At the conclusion of the plot, the voltage outputs on the rear vertical and horizontal axis terminals correspond to the last data point in the display. The PLOT LED is extinguished.

Following a plot, depressing the CRT ONLY pushbutton clamps the plotter output levels to zero volts.

In addition to horizontal and vertical axis plotter outputs, the 660 provides a pen lift output. This output is a switch closure used for lowering the pen on an analog plotter. When the PLOT button is depressed, the switch closure is made. Following a plot, when the CRT ONLY pushbutton is depressed the switch closure is opened.

In the "wake up" state the 660 is placed in the CRT ONLY mode. The define auxiliary is specified to support the 134A Digital Plotter and the 136A Digital Plotting Adapter via RS232.

DISPLAY MEMORY

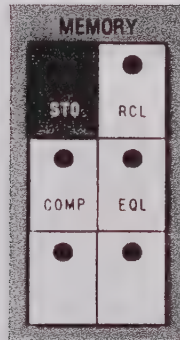
15. DISPLAY MEMORY Controls

FIGURE 15A

The DISPLAY MEMORY controls are shown in Figure 15A. These controls permit storage, recall, comparison, and equalization of data. A single screen image of one or two traces may be stored in its entirety. A stored screen image may be recalled for display at a subsequent point in time. When data is recalled, the display reflects the control status of the instrument at the time the data was stored, even though control changes may have been made between the time the data was stored and recalled.

Facility is provided to compare the stored measurement with its currently measured equivalent. When two traces

have been stored from a single screen image, the comparison is limited to two display traces, one from the currently measured function and one from the stored function. Either of the two stored traces may be compared.

If the stored information is a transfer function, it may be used to equalize a currently measured transfer function, transmissibility function, or impulse response. Equalization is a means of correcting for phase and amplitude shifts introduced by test measurement components external to the 660. This function is particularly useful when analyzing data which has been tape recorded.

When the STO pushbutton is depressed, the currently displayed screen image, one or two traces, is stored in a separate display storage memory. The entry/recall field indicates that storage has occurred by displaying the message DATA STORED as shown in Figure 15B.

Depressing the RCL button causes the stored display to replace the currently measured display. Depressing this pushbutton a second time reverts the display to the currently measured function that was on display before the RECALL button was first depressed. When the RECALL button is depressed, the screen annotation reflects the status of the instrument at the time of storage. All parameters that may

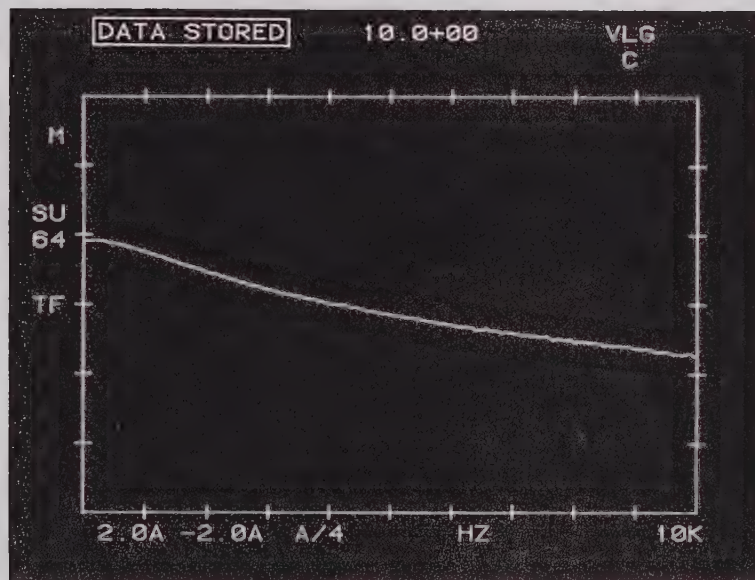


FIGURE 15B

be recalled through the entry/recall field reflect the status of the instrument at the time the data was stored. When the RCL button is depressed the second time, the currently measured function returns to the CRT with all parameters, gains, etc. restored to the condition that they held prior to the recall of the stored information.

Modifications to the stored panel settings are permitted in the recall mode. If the STO pushbutton is again depressed, the new front panel settings are stored with the old data.

Depressing the compare (COMP) pushbutton causes the display of the stored function and its currently measured equivalent as shown in Figure 15C. In Figure 15C the magnitude of two transfer functions is compared. The upper trace is always the current measured function, while the lower trace is the stored function. Note that only two traces may be displayed at one time. Hence, with a transfer function or any complex function or pair of single channel functions stored, the comparison must be made one trace at a time.

Comparisons can only be made between like functions acquired under similar conditions. For example, a probability density function cannot be compared with a transfer function. For this reason, if the COMP pushbutton is depressed and the currently displayed function does not match the stored function, the entry/recall field will display the error message RECALL, MATCH. This instruction advises the user to recall the stored

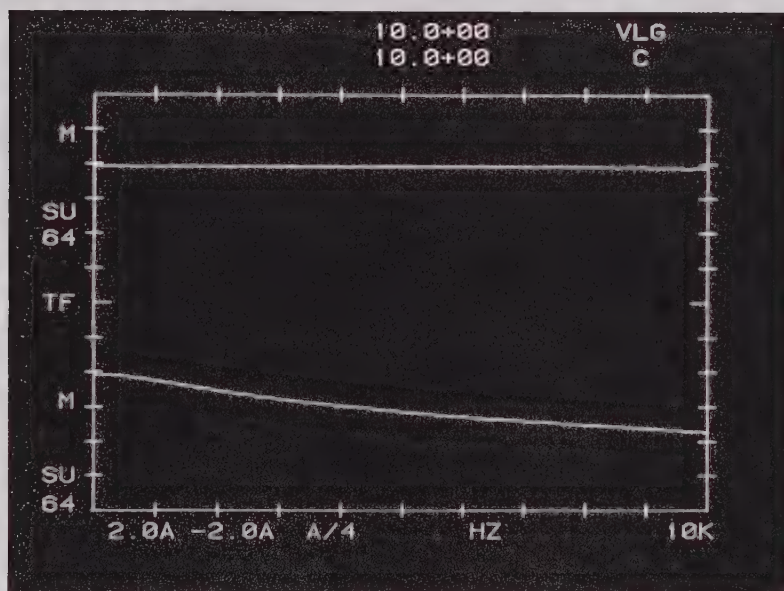


FIGURE 15C

information and then display its currently measured equivalent before depressing the COMP pushbutton.

Attempting comparisons with channel AB or format RI or format Ø MAG or format Nyquist will produce the error message ONLY 2 TRACES. This message instructs the user to select the channel or format of the currently measured function to produce only a single trace before depressing the COMP button.

If a transfer function has been stored, the equalize (EQL) pushbutton may be used. If the stored data is not a transfer function, the error message TF NOT STORED will be presented in the recall field. Equalization can be applied to the transfer function, transmissibility function, and impulse response. No other functions can be equalized.

Depressing the equalize pushbutton performs the complex division (equalization) of the currently measured transfer (or transmissibility) function by the previously stored transfer function. Complex division is equivalent to dividing the magnitude of the currently measured transfer (or transmissibility) function by the magnitude of the stored transfer function. Additionally, the phase spectrum of the stored transfer function is subtracted from the phase spectrum

of the currently measured transfer function. Figure 15D illustrates the equalized transfer function display of Figure 15C. Note that the function label has been modified by appending the prefix E for equalized to the function label TF. As shown in Table 9-1 modified labels of ETF, ETM, and EIR are possible.

When the currently selected measurement function is the impulse response, the equalization operation is first applied to the currently measured transfer function. Next, this equalized transfer function is inverse Fourier transformed to provide the equalized impulse response (EIR).

Attempting to depress the RCL, COMP, or EQL pushbuttons without previously storing a screen image will result in the entry/recall error message NO STORED DATA. This message indicates that the user must first store a screen image before attempting to use one of these functions.

In the "wake up" state no data is stored.

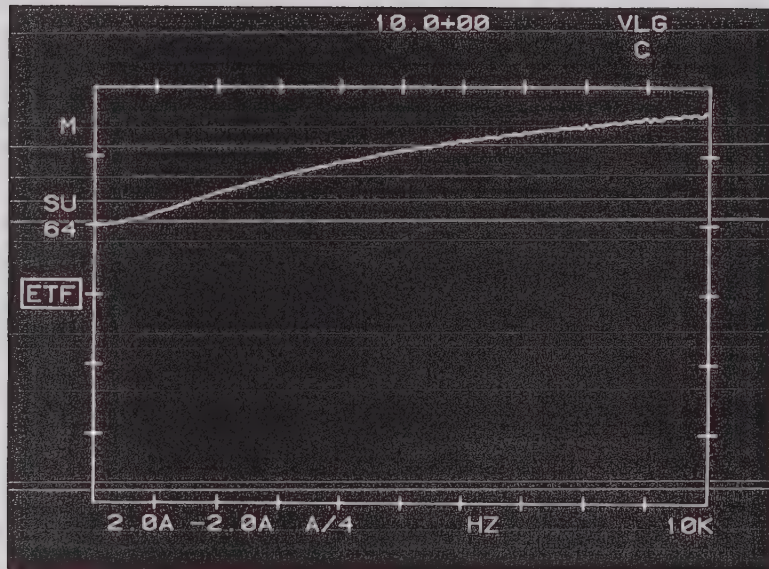


FIGURE 15D

CALCULATION CONTROL GROUP

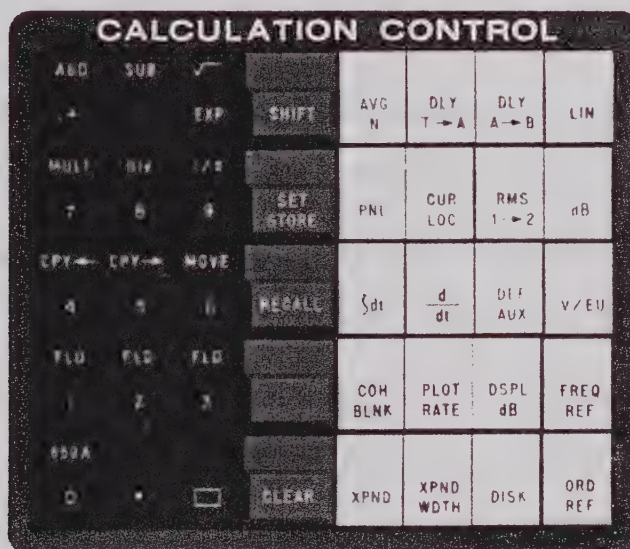
16. CALCULATION CONTROL

FIGURE 16A

Figure 16A illustrates the calculation control group. This control section is used to enter numeric information to the processor, to recall operating statuses of the instrument, and to modify the behavioral performance of the 660. Transactions through the calculation control are displayed in the entry/recall field as they occur. Unless deliberately cleared, or otherwise used, the entry/recall field always displays the last transaction conducted with the calculation controls.

Four types of transactions may be conducted.

These include:

1. Data may be entered using the SET/STORE key.
2. Information may be interrogated using the RECALL key.
3. An operation or characteristic initiated through a SET STORE command may be returned to the "wake up" state condition by using the CLEAR key.
4. Special operations involving the ENTRY/RECALL field are initiated through the SHIFT key.

Data entries are always made with a left-to-right sequence. A number is typed, followed by touching the SET STORE key, and normally followed by touching one of the twenty white buttons on the righthand side of the calculation control group. Data entries may be made in integer or floating point format. The EXP key is used to enter exponents. This key permits direct floating point entry. For example, the number 35,000 may be entered using the keystroke sequence 3, 5, EXPonent, 3 (35 times 10^3). All entered numbers are assumed to be posi-

tive unless the minus (-) key is depressed before depressing either the EXP or SET/STORE keys. Exponents, when used, are assumed positive unless the minus key is depressed after touching the EXP key and before depressing the SET STORE key. Leading zeros are ignored and the use of the decimal point is optional. There is no one correct way to enter a number. Any of several possible entries can be valid. For example, to enter the number -.018 all three of the following keystroke sequences are valid:

1. Minus, decimal point, 0, 1, 8
2. Minus, 1, 8, exponent, minus, 3
3. Minus, 1, decimal point, 8, exponent, minus, 2

Most data entries involve entering a number, followed by the SET STORE, and followed by one of the twenty white push-buttons. The exceptional operations are to explicitly set the display gains and the cursor location from the keyboard. Refer to Section 13 for direct cursor setting and to Section 12 for direct gain setting.

The use of the decimal point is optional in normal data entries.

Depressing the CLEAR key clears the entry/recall field. This key may be used to eliminate an erroneous numeric entry. Depressing the CLEAR key, followed by one of the twenty white calculation control keys will clear that function to its "wake up" state condition.

Depressing the RECALL key, followed by one of the twenty white keys will cause the previously entered value to be displayed in the entry/recall field. Thus, any parameter of significance can be brought to display prior to photographing or hardcopying the CRT image. Further, any numeric entry typed through the calculation control group without the following SET STORE and function button sequence may be left on display for hardcopy. This permits entering identification numbers on screen images.

The twenty white calculation control keys each have defined functions. These are listed, with a description of their use and their "wake up" state conditions, in Table 16-1. The DEF AUX key is discussed in greater detail in Section 19. Appendix A reviews entry/recall field messages that may be generated by improper use of the CALCULATION CONTROL. The following figures illustrate typical operations conducted through the calculation control group.

In Figure 16B the screen image of a captured transient time history is shown. The left most data point in this display is the first one which satisfied the transient conditions specified by the capture controls. In this instance, it is desired to view some information prior to trigger conditions.

In Figure 16C a similar transient has been captured after typing the sequence minus, .125, SET, DLY T→A. This sequence established an anticipation (negative delay) between the trigger point and the first data point held. Notice that the capture point has been moved to 12.5% (.125) of the time window. Delays ranging from -1 to +63 time windows with resolution of 1/1024 windows may be entered through this key. Additionally, delays between channel A and B of 0 to 64 time windows may be entered using the DLY A→B key.

Figure 16D illustrates an RMS spectrum. Figure 16E shows the same data after the keystroke sequence, 2, SET, $\int dt$, has been made. This keystroke entry must be made while viewing a single channel frequency function. The result of this keystroke entry provides artificial integration for the viewed channel. One or two integrations may be specified. Artificial integration is performed by $j\omega$ division in the frequency domain. Thus, if the data in Figure 16D had represented an

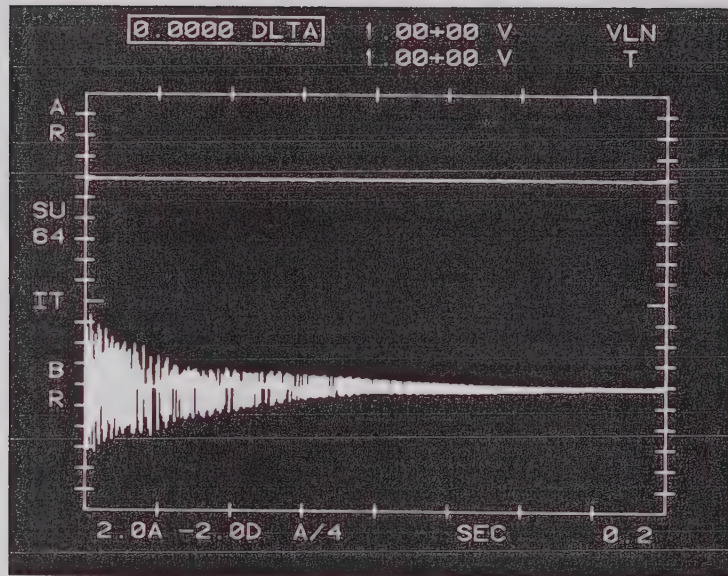


FIGURE 16B

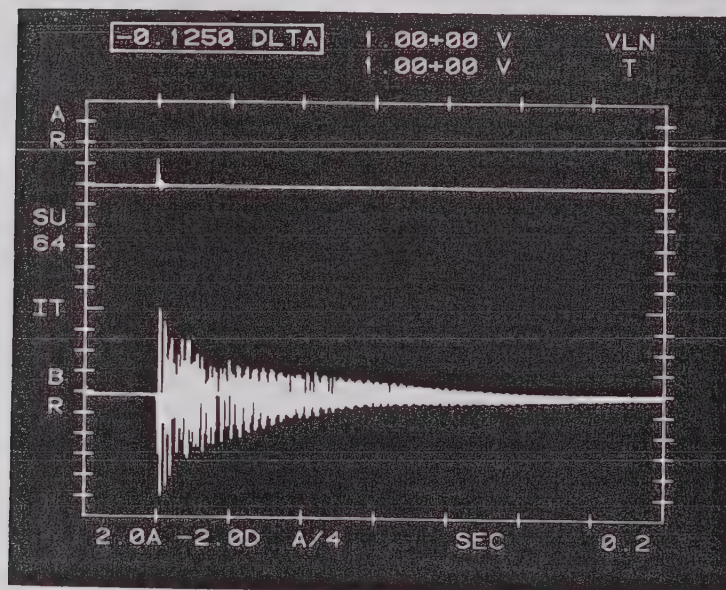


FIGURE 16C

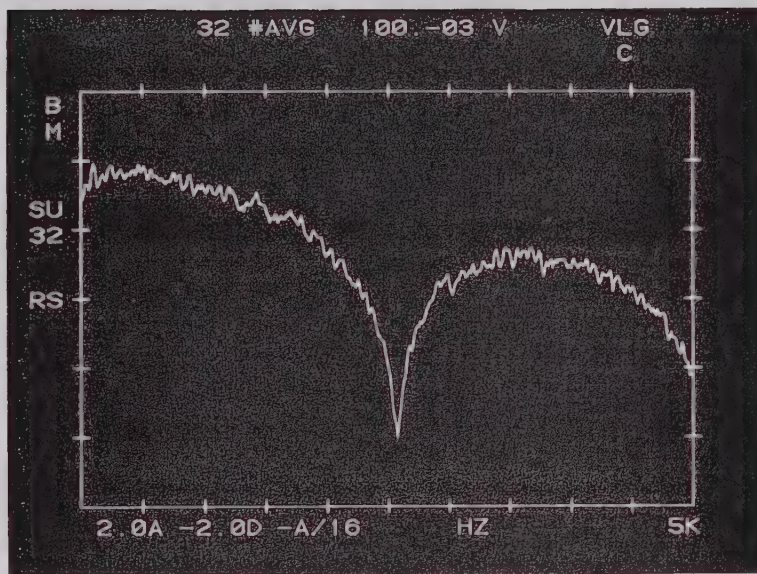


FIGURE 16D

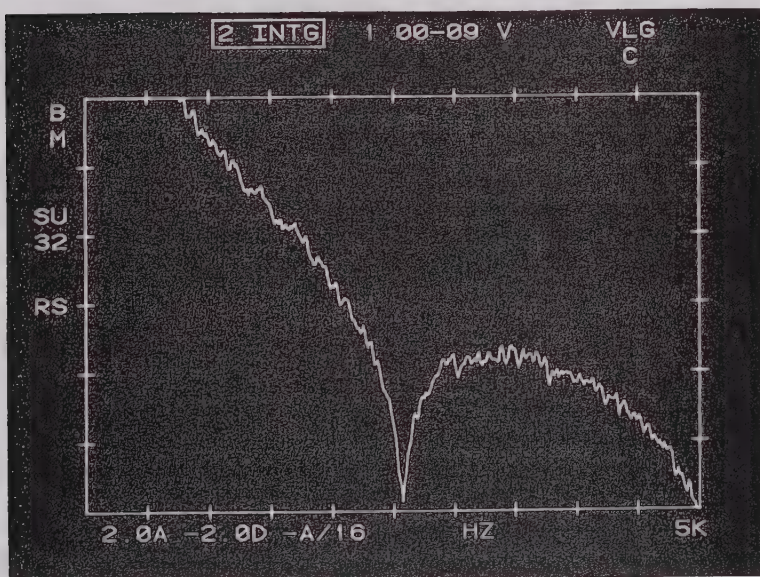


FIGURE 16E

acceleration spectrum, then that in Figure 16E would have represented a displacement spectrum.

It is sometimes desirable to change the display range. Figure 16F presents the same data as that of Figure 16E, but the keystroke sequence, 80, SET, DSPL dB, has been entered. This entry changed the range of display from the "wake up" state of 60 dB to 80 dB. Selections from 20 to 160 dB, in 20 dB steps, may be made.

The coherence function is often used to qualify the believability of a transfer function (or other cross property function) as a function of frequency. The qualification can be activated in the Model 660 by entering the keystroke sequence, .9, SET, COH BLNK. This sequence specifies a coherence blanking level of 90%. The transfer function displayed in Figure 16G is blanked at all frequencies where the associated coherence function is less than .9.

Other important calculation control operations include establishing volt/engineering unit scale constants. These may be entered by using the V/EU keys or the LIN and dB keys in conjunction with the cursor. The FREQ REF and ORD REF keys are also used in conjunction with the cursor to modify horizontal readouts. The CUR LOC key may be used to store up to ten cursor locations for immediate recall through the

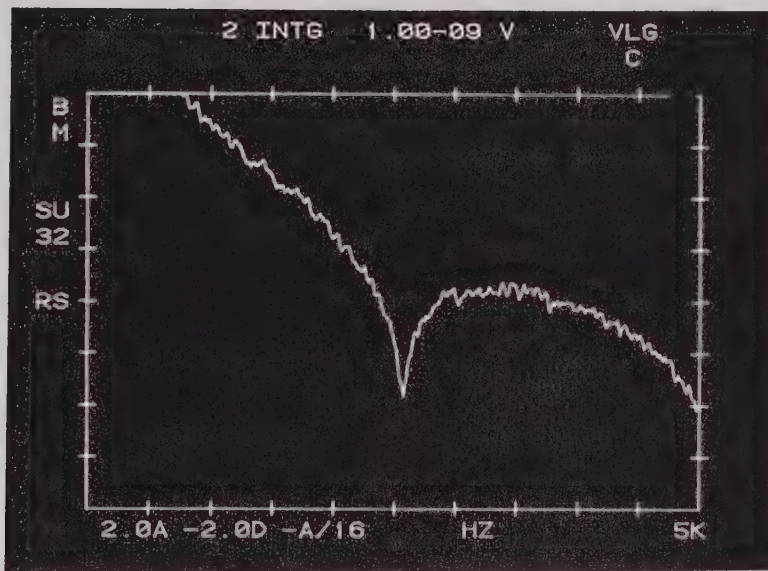


FIGURE 16-F

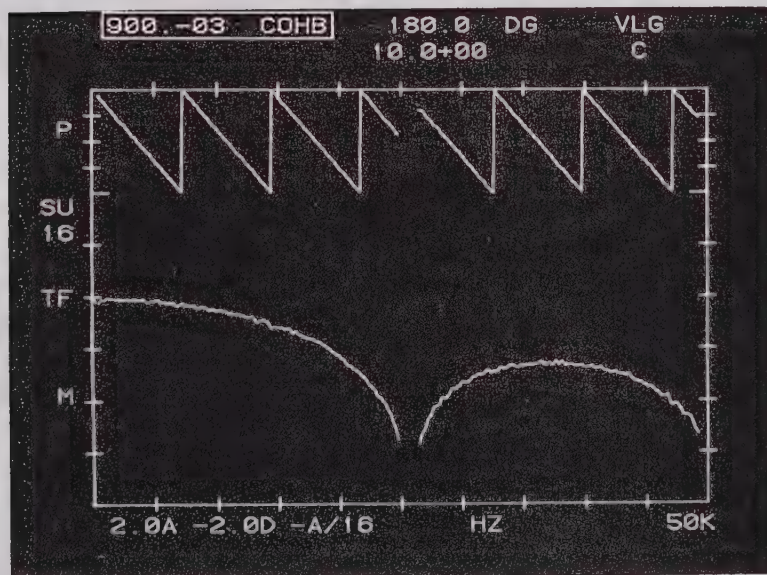


FIGURE 16-G

keyboard. The entire operating status of the front panel may be stored for future use by using the PNL key. This key permits storing up to ten entire front panel statuses so that they may be rapidly recalled with a single key sequence. Stored panel settings are retained even if the instrument is turned off.

Obviously, the calculation control group expands the versatility and flexibility of the 660. This group of controls is the key to tailoring the instrument's response to the user's needs. Table 16-1 summarizes the operations provided by this control group.

Table 16-2 summarizes the entry field operations available. These functions are activated by depressing the blue SHIFT key followed by a black numeric key to execute the operation indicated on the upper portion of each black key. These operations are separated into three types, namely, math, text, and informational.

The math feature allows numbers to be brought to the entry/recall field, operated upon (chaining calculations allowed), and then used to "SET" all available functions. For example, to multiply 3.1 by 4.2; add 6.1; take the square root; and finally set the result as upper display gain (full screen

TABLE 16-1

CALCULATION CONTROL KEY FUNCTIONS

<u>FUNCTION</u>	<u>SEQUENCE</u>	<u>DESCRIPTION</u>
1a. Set N, the number of spectra in the average	*Number (1-9999) SET AVG N	Causes averaging to stop after N spectra in the SUM or DIFFERENCE averaging modes, or determines the averaging time constant (speed of response) in Exponential. (In Ex, the next lower power of "2" is automatically employed.) Averaging in PEAK and SWEEP modes continues until STOP is pushed, regardless of N. In Ex (only), can change N without stopping averaging. (Initialized to "16").
1b. Reads N	RECALL AVG N	Number of spectra averaged to the moment appears in the display.
2a. Set time from a trigger to the start of CH A time window	*Number (-1.000 to 63.000 for "1K") *Sign (-means anticipation) SET DLY T→A	Delays (+) or anticipates (-) the capture of a transient from either an external trigger or a trigger level on the transient itself (see CAPTURE CONTROL) in terms of time windows. Resolution of the setting is 1/1024 of a time window or approximately .001 ("in 1K CH A-B mode"). The time window is determined by the setting of FREQUENCY RANGE. (For DUAL 1K mode, maximum is 31 time windows and resolution is 1/2048 time windows or approximately .0005).
2b. Read time from trigger	RECALL DLY T→A	(Initialized to "000" time windows, i.e., no delay with the left edge of the time display the instant of triggering).

(+) All numbers are assumed positive if no sign is entered. * Indicates number is stored with panel setting with PNL mode. "Initialized" number is automatically set when the unit is turned on or when SYStem ReSeT is pushed. () After number indicates the range of possible numbers.

TABLE 16-1 (Con't.)

CALCULATION CONTROL KEY FUNCTIONS

<u>FUNCTION</u>	<u>SEQUENCE</u>	<u>DESCRIPTION</u>
3a. Set time delay between CH A and CH B	*Number (0.000 to 64.000) DLY A → B	When collecting and processing two channels of data, sets time delay of CH B data with respect to CH A data in terms of time windows in order to compensate for delays inherent in the experiment, e.g., transport delays. Resolution of setting is 1/1024 x time window or one sample. Time window is determined by setting of FREQUENCY RANGE.
3b. Read time delay from CH A to CH B	RECALL DLY A → B	(Initialized to "0", or no delay).
4a. Set calibration at cursor in engineering units	Number EXP Sign Number (0 to 33) SET LIN	When displaying a single ch. INSTANT Spectrum or RMS Spectrum, a known amplitude reading is assigned to a spectrum element identified with the cursor (cursor in LINear EU). Exponent seeks a multiple of "3" and the decimal point automatically readjusts for no more than 3 decimal places. Two different EU calibrations can be entered (ABS/REL). The RELative number can be entered to allow measurement of amplitude differences from one spectrum peak to another.

RECALL DEFAULTS TO ITEM 6

TABLE 16-1 (Con't.)
CALCULATION CONTROL KEY FUNCTIONS

<u>FUNCTION</u>	<u>SEQUENCE</u>	<u>DESCRIPTION</u>
4b. Measure in engineering units	(Reads at all times in the annotation in LIN-EU settings of AMPLITUDE UNITS buttons)	SEE ITEM 6
5a. Set calibration at cursor when reading amplitudes of frequency functions in dB	*Sign (+,-) *Number (0.0 to 299.9) SET dB	When displaying single channel INSTANT SPECTra or RMS SPECTra, a known dB reading is assigned to a spectrum element identified with the cursor. Two different dB calibrations can be entered, one in ABSolute, one in RELative.
RECALL DEFAULTS TO ITEM 6		
5b. Read calibration in dB of frequency function	(Reads at all times in the annotation in dB-EU settings of AMPLITUDE UNITS buttons)	SEE ITEM 6

TABLE 16-1 (Con't.)

CALCULATION CONTROL KEY FUNCTIONS

<u>FUNCTION</u>	<u>SEQUENCE</u>	<u>DESCRIPTION</u>
6a. Set sensitivity of test system (including analyzer) in volts per engineering unit	*Number *EXP *Sign (+,-) *Number (0 to 30) SET V/EU	When displaying single channel INSTANT SPECTra or RMS SPECTra, a known calibration equivalence is established between volts and engineering units. The exponent automatically seeks a multiple of "3" and the decimal point automatically readjusts for no more than 3 decimal places. (ABS/REL switch in AMPLITUDE UNITS must be in ABS).
6b. Read sensitivity in V/EU	RECALL V/EU	Reads sensitivity of both input channels in any dual channel display or dual channel function. (Initialized to 1.0 V/EU).
7a. Retain settings of panel controls and keyboard	Number (1 to 9) SET PNL	Stores all pushbutton settings and all keyboard settings indicated by "*". Also stores all other pushbutton settings (scales, modes, display, etc.). Does not store cursor location or AVERAGE START/STOP. Nine I.D. numbers are available. Total of 10 panel patterns can be stored (including "0", as defined below).
7b. Recall settings of panel controls and keyboard	Number (0 to 9) RECALL PNL	Re-establishes panel control settings indicated by "*" for each of ten numbered patterns. Panel settings at moment of recall are stored automatically as "0".

TABLE 16-1 (Con't.)

CALCULATION CONTROL KEY FUNCTIONS

<u>FUNCTION</u>	<u>SEQUENCE</u>	<u>DESCRIPTION</u>
8a. Retain current cursor location	Number (1 to 9) SET CUR LOC	Stores location of cursor in frequency displays when cursor is on.
8b. Recall past cursor location	Number (0 to 9) RECALL CUR LOC	When stored cursor locations are recalled, the present one is automatically stored as "0" and can be recalled as "0". (Initialized at mid-screen).
9. Calculate RMS power between two frequencies	Number "n" (0 to 9) Number "m" (0 to 9) RECALL RMS 1 2	RMS power between cursor locations "n" and "m" is calculated and displayed in the annotation. The horizontal values of the cursors are annotated in the input field and the field directly below the input field. If two spectra are displayed, both values are calculated and annotated with the upper center annotation corresponding to the value for the upper display and the lower center annotation corresponding to the value for the lower display.
	Number "n" (0 to 9) RECALL RMS 1 2	RMS power between the current cursor location and cursor location "n" is calculated and displayed in the annotation. If two spectra are displayed, both values are calculated.

TABLE 16-1 (Con't.)

CALCULATION CONTROL KEY FUNCTIONS

<u>FUNCTION</u>	<u>SEQUENCE</u>	<u>DESCRIPTION</u>
9.	CLEAR RECALL RMS 1 2	RMS power between cursor locations "1" and "2" is calculated and displayed in the annotation. If two spectra are displayed, both values are calculated.
	Cursor OFF RECALL RMS 1 2	RMS power for the full spectrum display is calculated and displayed in the annotation. If two spectra are displayed, both values are calculated and displayed in the annotation.
10a.	Convert acceleration to velocity to displacement (typ) by synthetic input integration *Number (0, 1, 2) SET dt	The effect of single (1) or double (2) integration of the data from CH A or B (set in single ch. display) is achieved by calculations in the frequency domain after processing; most commonly used to convert acceleration data to velocity to displacement. Applies to all subsequent displays or single or dual channel frequency domain functions. (If "0" is entered, previous integration is removed).

TABLE 16-1 (Con't.)

CALCULATION CONTROL KEY FUNCTIONS

<u>FUNCTION</u>	<u>SEQUENCE</u>	<u>DESCRIPTION</u>
10b. Recall whether integration has been applied	RECALL $\int dt$	Number displayed is number of times (2 max.) the data in CH A or B (recalled in single ch. display) has been effectively integrated. (Initialized at "0" or no integration).
11a. Convert displacement to velocity to acceleration (typ) by synthetic differentiation	*Number (0, 1, 2) SET d/dt	The effect of single (1) or double (2) differentiation of the data from CH A or B (single ch. display) is achieved by calculations in the frequency domain after processing; most commonly used to convert displacement data to velocity to acceleration. Applies to all subsequent displays of single or dual channel frequency domain functions. (If "0" is entered, previous differentiation is removed).
11b. Recall whether differentiation has been applied	RECALL d/dt	Number displayed is number of times (2 max.) the data has been effectively differentiated. (Initialized at "0" or no differentiation).

TABLE 16-1 (Con't.)

CALCULATION CONTROL KEY FUNCTIONS

<u>FUNCTION</u>	<u>SEQUENCE</u>	<u>DESCRIPTION</u>
12a. Select output for data transfer	Number (00-199) SET DEF AUX	(a) Selects output device, type of transfer, and format, (b) Selects format of output at cursor, (c) Turns off graticule and/or cursor, (d) Establishes the meaning of the AUX pushbutton, (e) Establishes type of device to be emulated See Summary of DEF AUX Codes, Figure 19-3.
12b. Read output selected	Number (0-10) RECALL DEF AUX	Places AUX code in recall field. See Appendix C.
13a. Set level of coherence, below which dual ch. freq. functions are blanked	*Sign (+ or -) *Number (.000 to .999) SET COH BLNK	Plus sign means blanking of dual ch. functions occurs only <u>after</u> averaging is stopped; minus sign means that blanking occurs <u>during</u> data collection while averaging. Zero means no blanking.
13b. Read and restore the coherence blanking level	RECALL COH BLNK	The previously set blanking level is read and the blanking operation resumes per (13a.) above. (Initialized at "0" or no blanking).
13c. Turn off coherence blanking	CLEAR COH BLNK	The blanking function is suppressed. The set level is retained and the function may be restored using RECALL.
14a. Set an X-Y plotter rate	*Number (1 to 5) SET PLOT RATE	1 = very slow, 2 = slow, 3 = medium, 4 = fast, 5 = very fast; all plot rates include automatic slow-down for large peaks to ensure faithful reproduction. (PLOT in OUTPUT TYPE starts X-Y plotting of any single display). (Initialized to 5).

TABLE 16-1 (Con't.)

CALCULATION CONTROL KEY FUNCTIONS

<u>FUNCTION</u>	<u>SEQUENCE</u>	<u>DESCRIPTION</u>
14b. Recall plotter speed	RECALL PLOT RATE	Places plot rate in recall field.
15a. Set the range of the log display	*Number (20 to 160 in 20's) SET DSPL DB	Lower number provides greater vertical resolution but less viewing dynamic range (Gain level shifts the range of the log display "down" for greater sensitivity or "up" for less sensitivity in 10 dB steps); number of scale marks on the vertical axis indicates display range, one mark for each 10dB.
15b. Recall log display setting	RECALL DSPL DB	(Initialized at "60").
16a. Read frequency relative to a reference	Number (0 to 100,000.000 or to 1.000 x 10 ⁵) SET FREQ REF	A reference frequency, identified with the cursor, is entered in Hz (directly or in scientific notation, e.g., "6.78 + 2 = 6.78 x 10 ² = 678), after which all subsequent frequency readings include the reference offset. For example, to read frequency modulation directly from sideband spacing, the cursor on the carrier might be assigned "0" Hz, after which the upper sideband might read "+25 Hz" and the lower "-25 Hz".

TABLE 16-1 (Con't.)

CALCULATION CONTROL KEY FUNCTIONS

<u>FUNCTION</u>	<u>SEQUENCE</u>	<u>DESCRIPTION</u>
16b. Recalls the frequency offset used in relative readings	RECALL FREQ REF	Reads the frequency in Hz (+ or -) of the display origin, based on SET-FREQ REF (16a above). (Initialized to "0", i.e. origin is 0 Hz). Clear only removes the use of frequency reference, does not return it to 0.
17a. Provides a readings directly in "orders of rotation"	Number (0.0001 to 99.9999) SET ORD REF	The order identified with the cursor is assigned a number and thereafter all readings (horizontal) will be referenced to it. For example, twice the frequency will be read as twice the set order, etc. Time domain displays will be read as "cycles" or "functions of a cycle".
17b. Recalls maximum order displayed	RECALL ORD REF	Reads Hz per order.
18a. Activate optional digital expander (if in-stalled)	Number (With- in band) SET XPND	The optional digital expander is activated. The entered number is the desired center frequency of the expansion window. Refer to Options Section for further details.

TABLE 16-1 (Con't.)

CALCULATION CONTROL KEY FUNCTIONS

<u>FUNCTION</u>	<u>SEQUENCE</u>	<u>DESCRIPTION</u>
18b.	CLEAR SET XPND	Similar to 18a. The center frequency of the expansion window is the current cursor frequency.
18c.	CLEAR XPND	Turn off expander and restore baseband display.
19a. Window width control for optional digital expander (if installed)	Number SET XPND WDTN	The window width is set to the available width which includes the set number. If the entered number is negative, the expansion ratio is set directly. Refer to the Options Section for further details.
19b.	RECALL XPND WDTN	The entry field and the cursor horizontal field display the lower and upper bounds of the expansion window.
19c.	CLEAR XPND WDTN	The decimator ratio is set to its "wake-up" state. (Decimated by 8).
20. Control of the optional Data Recorder Adapter (if attached)	DISK	Refer to the Data Recorder Adapter Manual for the proper control sequences.

TABLE 16-2

SUMMARY OF SHIFT KEY OPERATIONS

Calculation Control Sequence	Button Label	Description
SHIFT ; Blnk	none	No Operation
SHIFT ; '●'	none	Entry/recall field is annotated with software revision level number.
SHIFT ; '0'	LOGO	Entry/recall field is annotated with NICOLET 660A.
SHIFT ; '1'	FLD	Entry/recall field is annotated with horizontal cursor position contents.
SHIFT ; '2'	FLD	Entry/recall field is annotated with cursor amplitude upper field contents.
SHIFT ; '3'	FLD	Entry/recall field is annotated with lower cursor amplitude field contents.
SHIFT ; '4'	CPY⇒	Copy text lines (see text option section).
SHIFT ; '5'	CPY⇐	Copy text lines (see text option section).
SHIFT ; '6'	MOVE	Move text line (see text option section).

TABLE 16-2

SUMMARY OF SHIFT KEY OPERATIONS

Calculation Control Sequence	Button Label	Description
SHIFT ; '7'	MUL	Multiply operation.
SHIFT ; '8'	DIV	Divide operation.
SHIFT ; '9'	1/X	Inverse operation.
SHIFT ; '+'	ADD	Add operation.
SHIFT ; '-'	SUB	Subtract operation.
SHIFT ; 'EXP'	$\sqrt{\quad}$	Square root operation.

value), the sequence is:

1. Enter: 3.1 Follow normal procedures
2. SET SET also places value in math accumulator

3. Enter: 4.2

4. MUL Sequence SHIFT; '7'

Intermediate result of 13.02 should appear in the Entry/Recall field.

5. Enter: 6.1 NO CLEAR, simply enter new number

6. ADD Sequence SHIFT; '+'

Intermediate result of 19.12 should appear.

7. $\sqrt{\quad}$ Sequence SHIFT; 'EXP'

Result of 4.373 should appear.

8. SET

9. GAIN Momentary deflection of the
(Upper) Upper Gain joystick sets the value

If the cursor is on, turning it off will display the FULL SCALE of each trace. This should confirm that the results of the calculation were used to SET the full scale of the upper trace.

In general, the data used in the calculations may be brought to the entry/recall field in any fashion available. The results are always shown in four place floating point no-

tation, unlabelled, ready to be used as future inputs. The math results are also placed back in the math accumulator to provide the chaining capability.

SECTION 17

POWER ON CONDITIONAL STATES (WAKE-UP STATE)

17. Power On, System Reset, and Clear Panel State

In this state the 660 Spectrum Analyzer is set to the following, with NICOLET 660 appearing in the entry/recall field.

MODE - DUAL 1K

FUNCTION - INST SPEC

AVERAGE - SUM (Averager Off, # Avg = 0)

DISPLAY — CH - A/B

FORMAT - MAG

MEMORY - No lights on, no data stored

SCALES — AMPL - LOG

FREQ - LIN

OUTPUT TYPE - CRT ONLY

AMPLITUDE UNITS - LIN, V, ABS, (PER Hz-Off)

CAPTURE CONTROL - CONT, REL, (not in HOLD, not
in ARM)

Cursor Location - Midscreen

In addition, the CALCULATION CONTROL settings are as follows:

AVG N - 16
DLY T→A - 0
DLY A→B - 0
V/EU - 1 V/EU A & B
Rel - 1
Int/Df - Off (0)
COH BLNK - Off (0.00)
PLOT RATE - 5 (Fastest)
DSPL dB - 60 dB
FREQ REF - 0 Hz
ORD REF - 1 Hz/Order

The DEF AUX settings are:

0	1	Output to 134A Digital Plotter over RS232
1	0	50% Redundancy, Normal Trigger
2	0	Graticule, Annotation, Data "On"
3	4	I/O Format: Binary, No Block Fill
4	0	(Optional) Sine Wave Cursor/Trans- latable Noise "Off"
5	5	ASCII OUTPUT Buffer Terminator: (CR), (LF), (ETX)* *Last Buffer Only
6	1	Handshake "On"
7	0	Diagnostics Disabled
8	0	No Pagination
9	0	No Text on Display
110		Sine Wave At Cursor Amplitude of 1 Volt Peak

SECTION 18

OPTIONS

This section of the instruction manual contains instructions for operating options purchased for the 660 Dual Channel Analyzer.

Current available options and instructions for those options included in this section are as follows:

Option -2D Digital Expander

Option -6 Text Entry Option

Option -7 Excitation Source Option

Option -2D Digital Expander

The Digital Expander (Option -2D) for the 660 Dual-Channel Analyzer provides increased frequency resolution. Seven different expansion ratios allow windows to be used which range in width from .64 Hz (5 Hz, expansion ratio 8) to 12,500 Hz (100 KHz, expansion ratio 8). The basic resolution of the 660, 400 points in dual-channel operation and 800 points in single-channel operation, is retained.

The center frequency of the expansion window can be set as resolutely as $1/100,000$ of the selected range, for example, .00005 Hz in the 5 Hz range. The maximum resolution in single-channel operation is $1/800$ of the selected window width, for example, 8 mHz for a .64 Hz window.

The anti-aliasing filters of the 660 remain operative when the Digital Expander is used. Since the same resolution may be available with different low-pass filters in use, an optimum choice can be made.

Most 660 features are not effected by expansion. All functions in the CALCULATION CONTROL section are still available, including interchannel delays, differentiation, and integration. All averaging modes may still be used, and the data can be displayed in any format desired.

1. XPND

The XPND pushbutton in the CALCULATION CONTROL section is used to activate the Digital Expander. The desired center frequency is entered in the current horizontal units of measure (Hz, CPM, ORDERS), followed by SET XPND. This sequence activates the Digital Expander and sets the center frequency. The current cursor location may be used as the expansion window center frequency by entering the key sequence:

CLEAR SET XPND. When the Digital Expander is enabled, the upper (right) and lower (left) frequency extremes in the current expansion window are annotated in the upper-left of the screen. See Figure D-1. This annotation can be recalled at any time by the key sequence: RECALL XPND, providing the Digital Expander is on. If the Digital Expander is not on, this sequence will activate the Digital Expander and set the center frequency to that used in the last expansion. The upper and lower frequencies are annotated as in Figure D-1.

2. CLEAR XPND

The key sequence: CLEAR XPND, causes the Digital Expander to be turned off, annotation made in the entry field, and to return to a baseband display. Depressing a MODE pushbutton, or changing the FREQUENCY RANGE switch, will also cause the Digital Expander to be turned off. The center frequency is

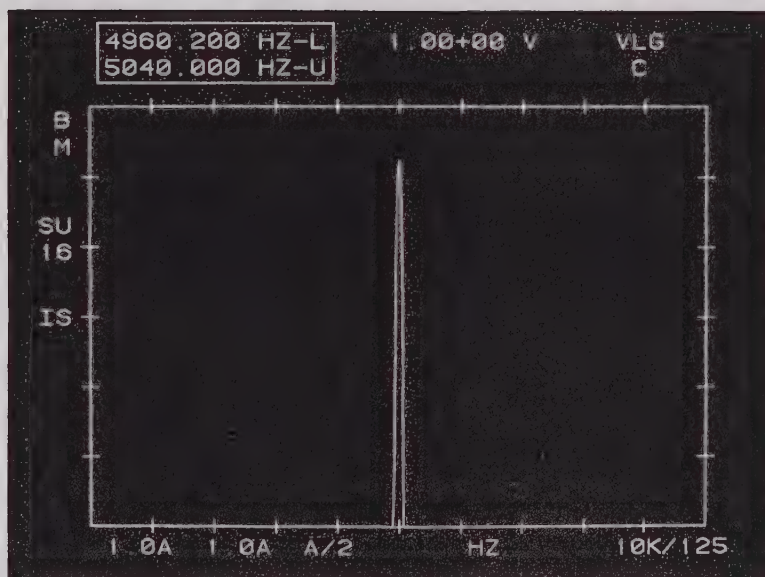


FIGURE D-1

retained internally, and pressing RECALL XPND will restore the same window at the same frequency assuming it is valid in the current mode and range.

The ratio of the center frequency to the selected frequency range is stored within the 660. Therefore, if the frequency range is changed, the new center frequency will be the same proportion of the frequency range as the previous.

3. XPND WDTN

The XPND WDTN pushbutton is used to modify the window width and expansion ratio. The window width and expansion ratio are related: $\text{FREQUENCY RANGE} = (\text{Expansion Ratio})(\text{Window Width})$. The wake-up state is an expansion ratio of 8. The expansion ratio is used internally and remains constant unless specifically altered by the operation. The valid combinations of frequency range and expansion ratio are given in Table D-1.

When the Digital Expander is activated through use of the XPND pushbutton, the actual expansion ratio is displayed in the lower right-hand corner of the screen. Except in the 100K range, the number will be 2.4% smaller than the entries in Table D-1. The table gives nominal values.

The window width may be set explicitly in the current units of measure (Hz, CPM, ORDERS) by pressing the sequence: (number) SET XPND WDTN. If the width requested is not an

TABLE D-1

FREQUENCY RANGES AND EXPANSION RATIOS

FREQUENCY RANGE (filter cutoff (Hz))	NOMINAL RESOLUTION OF SETTING	EXPANSION RATIOS AND WINDOW WIDTHS (Hz)						
		X8*	X16	X32	X64	X128	X256	X512
100K	1.0	12500	6250	3125	1562	781.2	390.6	195.3
50K	0.5	6400	3200	1600	800	400	200	100
20K	0.2	2560	1280	640	320	160	80	40
10K	0.1	1280	640	320	160	80	40	20
5K	0.05	640	320	160	80	40	20	10
2K	0.02	256	128	64	32	16	8	4
1K	0.01	128	64	32	16	8	4	2
500	0.005	64	32	16	8	4	2	1
200	0.002	25.6	12.8	6.4	3.2	1.6	0.8	N/A
100	0.001	12.8	6.4	3.2	1.6	0.8	N/A	N/A
50	0.0005	6.4	3.2	1.6	0.8	N/A	N/A	N/A
20	0.0002	2.56	1.28	0.64	N/A	N/A	N/A	N/A
10	0.0001	1.28	0.64	N/A	N/A	N/A	N/A	N/A
5	0.00005	0.64	N/A	N/A	N/A	N/A	N/A	N/A

*Initialized condition on power turn on or RESET.

exact width from Table D-1, then the next larger size window for that frequency range will be selected. If, however, the window requested is larger than the largest valid window, the largest valid window will be selected. The window width selected will be annotated in the upper left-hand corner of the screen, as in Figure D-2. Alternatively, a decimation ratio can be set by the key sequence: — (number) SET XPND WPTH. If the user attempts to set a number which is not one of the seven listed in Table D-1, the next smaller ratio will be selected. The sequence: RECALL XPND WPTH will cause the current window width to be annotated on the screen, as in Figure D-2. CLEAR XPND WPTH will cause the wake-up state, expansion ratio of 8, to be selected.

None of the key sequences involving the XPND WPTH push-button cause the Digital Expander to be activated or deactivated. If an invalid width is requested, no change will result. In addition, all of the sequences involving the XPND WPTH push-button can be executed whether the Digital Expander is on or off.

4. Analysis Length

Due to the high resolution of the Digital Expander, the analysis may take appreciable amounts of time, especially in the lower frequency ranges or higher expansion ratios. The

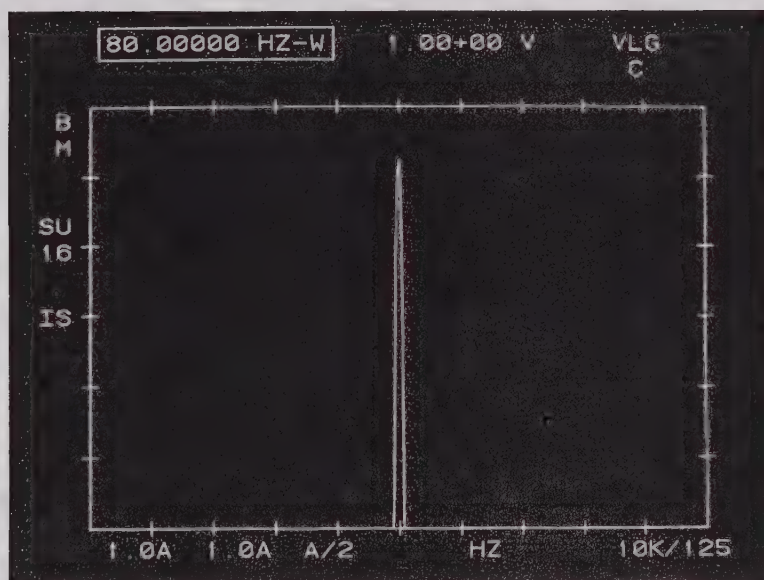


FIGURE D-2

exact time may be found by multiplying the TIME WINDOW, located on the front panel of the 660, by the expansion ratio.

5. Interpretation of Expansion Parameters Stored in Data Buffer 0 (Reference: Section 19)

The two parameters stored in data buffer 0 which pertain to the Digital Expander are STDCRN (1 byte at offset 44), and STRXR (5 bytes at offset 45). STDCRN stores the code for the expansion ratio currently in use. The expansion ratio can be determined using the contents of STDCRN and the table below. All codes other than 1 through 7 are invalid. On power-up, this byte is set to 1.

<u>STDCRN</u>	<u>Expansion Ratio in FREQ RANGE 5 - 50 kHz</u>	<u>Expansion Ratio in 100 kHz Range</u>
1	7.8125	8
2	15.625	16
3	31.25	32
4	62.5	64
5	125.0	128
6	250.0	256
7	500.0	512

STRXR contains the ratio of the current or most recent center frequency to the maximum frequency in that range. The ratio is stored internally with scale factors applied. The following formula may be used to calculate the center frequency from the contents of STRXR.

$$\text{center frequency} = (\text{STRXR})(10^{-5})(\text{frequency range})$$

STFRRD (1 byte at offset 28) can be used to determine whether or not the Digital Expander is currently on or off. If bits 1 and 7 are at 1, the Digital Expander is on.

6. Error Codes

The following errors may result from the use of XPND or XPND WDTN pushbuttons. Errors appear in inverted type in the upper-left of the display screen. The action which caused the error does not alter any system parameters.

<u>Error</u>	<u>Description</u>
NO EXPANDER	Attempt to SET, RECALL, or CLEAR expansion in a unit which does not contain Digital Expander Option -2D.
TURN ON CURSOR	Attempt to set location of window using cursor when cursor is off.
>MAX FREQ	Attempt to SET or RECALL a window beyond the maximum frequency of selected range.
<MIN FREQ	Attempt to SET, RECALL, or CLEAR center frequency or width that would cause the center to be less than 1/2 the expanded band.
EXIT COMP	Attempt to set window on active data in COMP which does not match stored data.
EXIT EQL	Attempt to set window on active data in EQL which does not match stored data.
FREQ MISMATCH	Attempt to set center of window on active data in COMP or EQL which does not match stored data.
STORED DATA	Attempt to change expansion state of stored data.

<u>Error</u>	<u>Description</u>
VIEW FREQUENCY	Attempt to SET or RECALL expansion in time domain or CORR mode.
XPND CONFLICT	Attempt to enter COMP or EQL on active data with expansion parameters not matching the parameters of the stored data.
N/A IN XPND	Attempt to enter format not allowed in expansion, such as INPT TIME, IMP RESP, or CORR.
MIN RANGE 5Hz	Attempt to SET or RECALL expansion or frequency range lower than 5 Hz.

The TEXT ENTRY OPTION enables the user to enter annotation from the front panel of the 660 without peripheral equipment. This feature adds another dimension to the report ready format available on digital plots and CRT photographs. See Figure T-1. The TEXT mode is a mode modifier allowing all normal processes, such as averaging, to proceed while the user prepares additional explanatory annotation for the display. The TEXT mode provides four, 45 character text lines. The lines may be selected, edited, and moved anywhere on the CRT display screen. Information may be hand entered, copied from the ENTRY/RECALL field, or entered using either the RS232 or the IEEE-488 interface. Once the annotation is entered it may be selectively hidden from view to permit selective plotting or PANEL selective recall of specific lines.

Certain 660 front panel controls take on temporary meanings in the TEXT ENTRY OPTION mode. The controls and functions are summarized in Table T-1.

1. Character Cursor Control

The character cursor is superimposed on the current character in the line, creating a reversed character image of a dark character on a light background. The cursor position

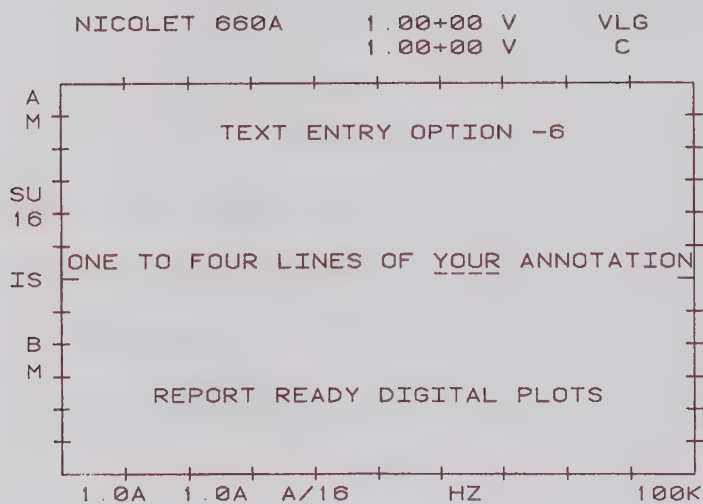


FIGURE T-1

TABLE T-1

SUMMARY OF TEXT LINE EDITING CONTROL KEYS

SECTION	KEY or JOYSTICK	FUNCTION
MODE	TEXT	ENTER/EXIT TEXT mode of operation
FUNCTION	TEXT 2	SELECT TEXT EDITING mode on field #2
	TEXT 3	SELECT TEXT EDITING mode on field #3
	TEXT 4	SELECT TEXT EDITING mode on field #4
TEXT ENTRY OPTION	12 Black Keys 4 Blue Keys	TEXT ENTRY TEXT ENTRY CONTROL
CALCULATION CONTROL	15 Black Keys Blue SHIFT Key	TEXT ENTRY TEXT OPERATION CONTROL (See COPY and MOVE functions)
CURSOR POSITION AND GAIN	Cursor Joystick	TEXT CHARACTER CURSOR Position control, unless MOVE function invoked, then TEXT line horizontal position control.
	Gain Joystick (Either)	During MOVE function, TEXT LINE vertical position control.

is controlled by the same joystick as the data cursor, and the TEXT mode temporarily usurps the use of this control. The character cursor does not wrap-around, but stops at the extreme of the line. Whenever a new text line is selected, the character cursor appears on the left-most character of that line.

2. Text Pad with Control

The 16 keys in the TEXT ENTRY OPTION pad are used to enter alphabetic and special character text. The four blue keys control the 12 black keys. The black keys are text entry keys. Discussion of each blue control key follows.

a. Select 3rd Character

Select 3rd character key is an alternate action key used to pre-select the third character or function of the next text key. If followed by the ABC text key, the C is placed in the string. This function is automatically terminated after each text key entry.

b. Select 2nd Character

Select 2nd character key is similar in function to the select 3rd character key, however, if followed by the ABC text key the B is placed in the text string.

c. INSert

INSert key is an alternate action key used to insert characters in the middle of an existing string. During

INSert, the new character is positioned at the cursor and the rest of the line is shifted to the right by one character. Characters falling off the right end are lost. Exiting TEXT or changing line selection automatically clears the INSert state.

d. RUB Out

RUB out key is used to eliminate the character at the cursor and shift the remaining characters left one position. A blank is shifted into the right-most (45th) position.

e. Select 3rd character, followed by RUB, places a NULL (internal end of character string indicator) at the position of the cursor. As long as the cursor is on this location, it is not interpreted as a NULL end of character string. Therefore, the remainder of the line can still be viewed. Moving the cursor off this point allows the NULL to take effect. The NULL is used to truncate a line for digital plotters preventing them from plotting the remaining blanks. Also, the NULL may be used to temporarily hide the remaining text line and permit multiple pre-stored texts to be moved up quickly and conveniently.

3. Numeric Pad

The black CALCULATION CONTROL keys are used to enter the indicated character into a text line. The EXP black key

serves to copy the contents of the 14 character ENTRY/RECALL field into the text line. All SHIFTed black key functions retain their identity. The CPY← (SHIFT:4) and CPY→ (SHIFT:5) are described in the line copying section. The MOVE (SHIFT:6) is described in the line positioning section. Note, that the CALCULATION CONTROL blue and white keys retain their function, such as RECALL: AVG N or CLEAR: DLY T→A). The black keys numeric entry function is used for text entry.

4. Line Copying

The complete 45 character line copying is to and from text line #1. This enables the user to define a common heading and copy it into other text lines for minor modification. Copying into a text line from line #1 is accomplished by selecting the destination text line (2,3 or 4), CPY← (CALCULATION CONTROL SHIFT:4). Copying from a text line to line #1 is accomplished by selecting the source text line (2,3, or 4), CPY→ (CALCULATION CONTROL SHIFT:5).

5. Text Line Positioning

Text lines may be positioned anywhere on the CRT display. After selecting the text line to be moved, issue a MOVE (CALCULATION CONTROL SHIFT:6). Horizontal motion is in 1/2 character steps controlled by the CURSOR POSITION joystick, while vertical motion is in 1/2 character steps controlled by either

GAIN joystick. The joystick control over line position is revoked as soon as another editing operation is performed such as INS. The line remains where positioned.

6. Selective Text Viewing

The user is provided with the ability to display one text line, all text lines, or none of the text lines. Text line display is controlled by the 90 series DEFine AUXiliary.

90 Series DEFine AUXiliary

90	No Text Displayed (Power-up Default)
91	Text Line #1 Only
92	Text Line #2 Only
93	Text Line #3 Only
94	Text Line #4 Only
95	All Text Lines Displayed

Consistent with all DEF AUX codes, this code is stored and recalled with PANELs, and DISPLAY MEMORY status. Note, the characters and position of the text lines are not stored; the display selection code (DEF AUX) is stored. This allows the user to view pre-stored lines via recalled panels.

When TEXT mode is entered, 95 DEF AUX is invoked. The current 90 series DEF AUX is saved and re-instated when TEXT mode is exited.

7. Exercise

The objective is to position the 4 lines, one above the other, in the upper-left hand corner of the data area within the graticule. Each line is to have its line number as its first character.

- a. Select TEXT mode: Depress the blue TEXT mode button. Note the character cursor appearing in the extreme upper-left corner of the CRT. This is TEXT LINE #1.
- b. Place a 1 in the first character of LINE #1: Depress CALCULATION CONTROL 1. See Figure T-2.
- c. Move TEXT LINE #1 to within graticule: CALCULATION CONTROL Sequence SHIFT:6. Note the CALCULATION CONTROL Sequence SHIFT:6 is referred to as MOVE in the remainder of the example. Also note that the character cursor moved to the beginning of LINE #1. Deflect the CURSOR joystick right or left for horizontal alignment. Deflect either GAIN joystick up or down for vertical alignment. Move the TEXT line about until the 1 appears just inside the graticule. See Figure T-3.
- d. SELECT TEXT LINE #2: Depress FUNCTION section blue key marked TEXT 2. The LED will indicate the completion of the selection. LINE #1 will remain where it was positioned. The character cursor will appear as the 1st character in LINE #2.
- e. Place a 2 in LINE #2: As in b (above) depress: CALCULATION CONTROL 2. See Figure T-4.

1

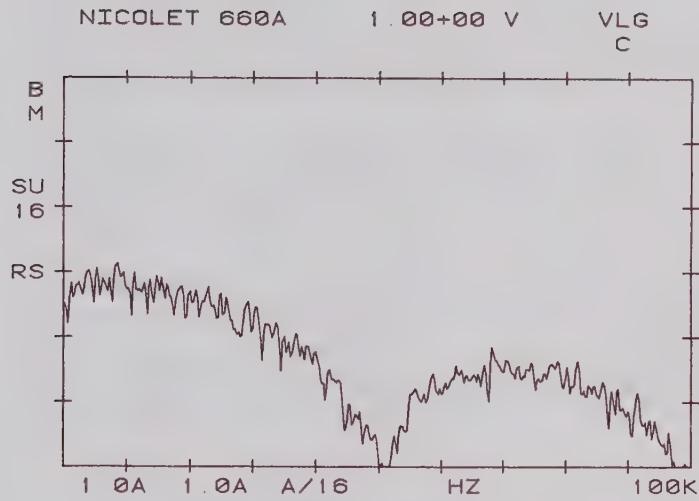


FIGURE T-2

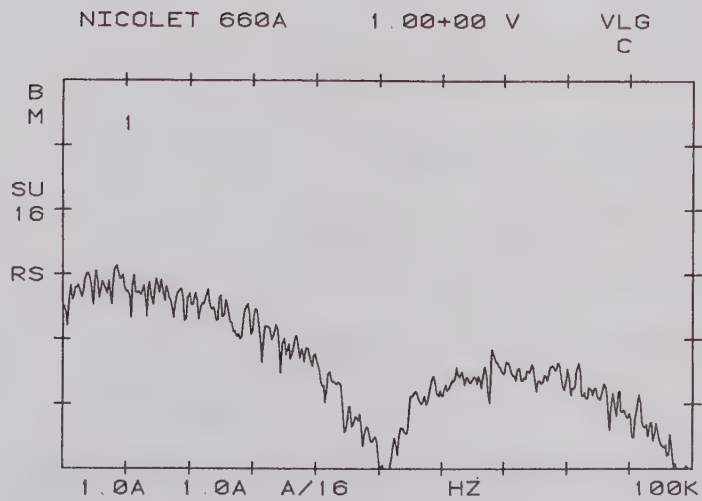


FIGURE T-3

2

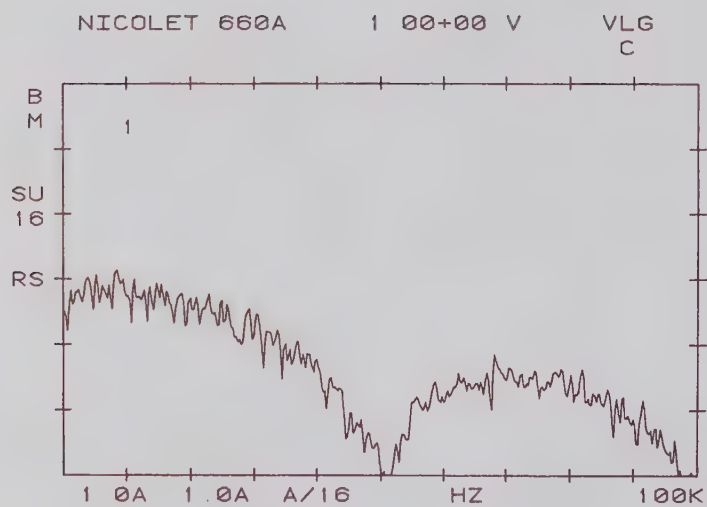


FIGURE T-4

- f. Move TEXT LINE #2 to below LINE #1: As in step c the CALCULATION CONTROL Sequence for MOVE will cause the character cursor to appear at the beginning of LINE #2, highlighting the 2 just entered. With the joystick controls, move this line to just below LINE #1. Notice that movement resolution is in half character width and height. See Figure T-5.
- g. Now that the selection, single number entry, and movement is understood, repeat the process for lines #3 and #4.
- h. At this point the 4 lines should be neatly stacked one over the other just within the graticule.
- i. Copy ENTRY/RECALL line contents into TEXT LINE #2. See Figure T-6.
1. Select FUNCTION: TEXT 2
 2. Move character cursor one step right with CURSOR joystick.
 3. Copy ENTRY/RECALL by depressing CALCULATION CONTROL: EXP.
- j. Insert ENTRY/RECALL field contents into TEXT LINE #2. See Figure T-7. CONTROL Sequence: RECALL; AVGN.
1. Fill ENTRY/RECALL field with something new, such as the CALCULATION CONTROL Sequence: RECALL; AVGN.
 2. Reposition character cursor between the 2 and the rest of the TEXT line.
 3. Depress INSert in the TEXT ENTRY control section. Blue key, LED should light.
 4. Copy ENTRY/RECALL field by depressing CALCULATION CONTROL: EXP.
Notice the original TEXT copied from the ENTRY/RECALL field moved to the right and the new text inserted.
- k. EXIT TEXT MODE: Depress TEXT MODE key thereby exiting TEXT MODE, and turning out the LED. Note that the TEXT lines disappeared. When TEXT mode was entered no lines were selected to view and now that condition is restored.

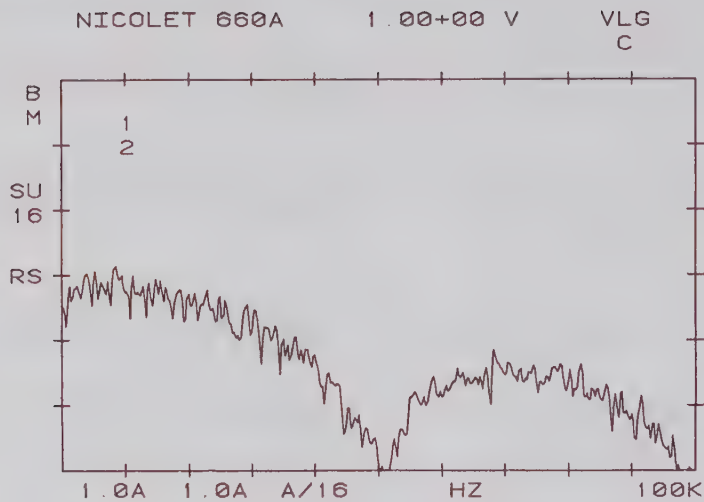


FIGURE T-5

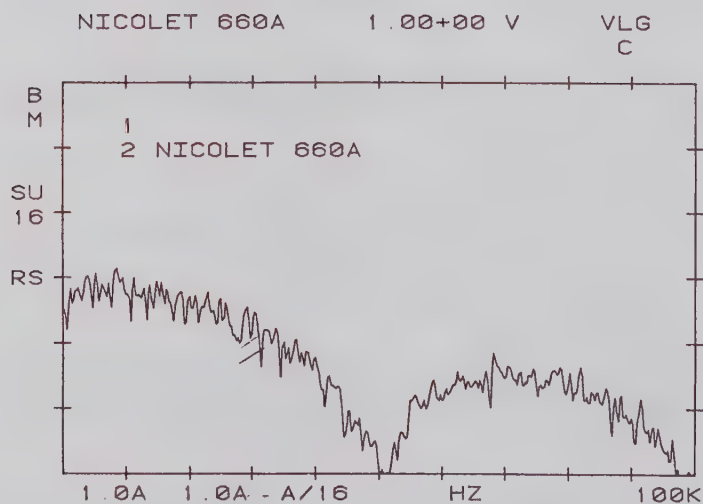


FIGURE T-6

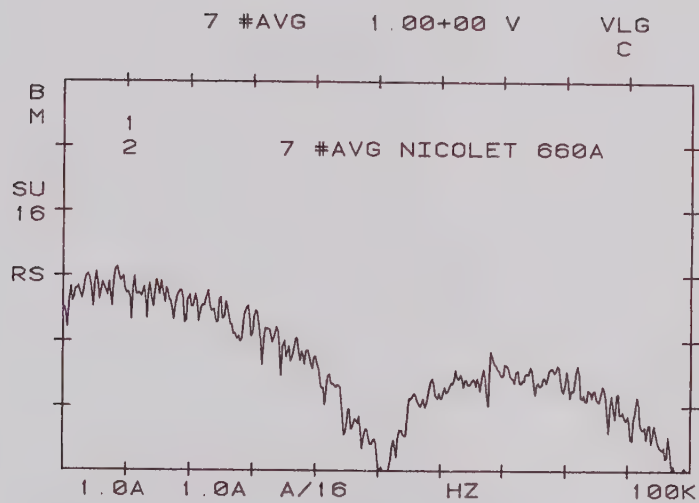


FIGURE T-7

1. Observe the effects of the following on the TEXT.

91; SET; DEF AUX
92; SET; DEF AUX
93; SET; DEF AUX
94; SET; DEF AUX
95; SET; DEF AUX
90; SET; DEF AUX

Option -7 Excitation Source Option

The Excitation Source (Option -7) for the 660 Dual-Channel Analyzer permits selection of one of three digitally controlled signals:

1. Sinewave At Cursor Frequency
2. Pseudo-Random Binary Noise
3. Periodic Binary Noise

The selected signal source is connected to the J109 BNC connector on the rear panel of the 660. Selection is via the DEF AUX button in the CALCULATION CONTROL section.

DEF AUX Setting

The DEF AUX button selects the signals and controls the amplitude. The 40 series of DEF AUX controls the signal select and the 100 series of DEF AUX controls the amplitude. The initial wake-up condition is 40 and 110 DEF AUX. No signal is present on the output BNC connector.

A. DEF AUX 40-43 - Signal Select

The different noise sources are enabled by the key sequence:

"X"	SET/STORE	DEF AUX
-----	-----------	---------

where X can be:	40	- Excitation Source Off (Wake-up State)
	41	- Sinewave at the Cursor Frequency
	42	- Pseudo-Random Binary Noise
	43	- Periodic Binary Noise

1. 40 DEF AUX - Excitation Source Off - The OFF position is the wake-up state of the excitation source; and no signal appears on the rear panel BNC connector.

2. 41 DEF AUX - Sinewave At Cursor Frequency - In this mode of operation, the output of J109 on the rear panel of 660 will be a digitally generated sinewave that will track the frequency at the cursor. The CURSOR TYPE switch must be in either the SINGLE or the HARMONIC position. The sinewave is generated on all ranges, and can also be used with the optional Nicolet Scientific Digital Range Translator. The resolution of the digital sinewave is 0.25 Hz.

3. 42 DEF AUX - Pseudo-Random Binary Noise - Pseudo-random binary noise is a noise source whose frequency spectrum is flat across the analysis range to within ± 3 dB of the spectral mean. With the optional Digital Range Translator invoked, the noise is band limited to concentrate the energy in the band of translation. The noise source will track all frequency windows and expansion ratios.

4. 43 DEF AUX - Periodic Binary Noise - The periodic binary noise source provides a noise pattern that will be repeated for each sample period. This pattern is a fixed 1024 point (1K Mode) or 2048 point (2K Mode) sequence which repeats at a rate specified by the input time window collection period.

B. DEF AUX 100-199 - Amplitude Controls

The amplitude of the excitation source is fully adjustable from 0.0 V to 9.9 V peak. The amplitude control is achieved

via the 100 series of DEF AUX. The wake-up state of this series is 110 which is equivalent to 1 V peak. This voltage will be the peak amplitude of the excitation source output. The voltage can be changed in 100 mv increments via the following key sequence:

"N" SET/STORE DEF AUX

where N is any value from 100 to 199. The voltage will be equal to:

$$\text{Peak Amplitude} = (N - 100) \times 100 \text{ mv}$$

C. Recall of Source or Amplitude DEF AUX

At any time the current source or amplitude may be recalled. To recall the signal type, the following key sequence is used:

4 RECALL DEF AUX

To recall the amplitude control setting, the following key sequence is used:

10 RECALL DEF AUX

Either of these key sequences recall the setting to the 660 entry field.

D. Error Messages

Error messages may result from the use of the DEF AUX button for the excitation source. Errors appear in inverted type in the entry field. The action which caused the error does not alter any system parameters. Possible errors include:

<u>Error</u>	<u>Description</u>
TURN ON CURSOR	Attempt to turn on sinewave at cursor with the cursor in the OFF position.
40-43	Attempt to set the 40 series DEF AUX to a number greater than 43.
000-199	Attempt to set the 100 series DEF AUX to a number greater than 199, or inputting an incorrect DEF AUX series.

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SECTION 19

DIGITAL INTERFACES TO THE 660

19.1 Available Interfaces

A. Introduction

In order to allow remote control of the 660 and enable the user to input and output data, three digital interfaces are provided on the back panel. These interfaces and the corresponding connector numbers follow:

- | | |
|-----------------|------|
| 1. IEEE-488 | J111 |
| 2. RS232-C | J112 |
| 3. Parallel A/D | J113 |

The data which is available via these interfaces includes, but is not limited to, digital time domain data, frequency domain data, averaged data, and front panel settings. A brief description of the interfaces is presented with in-depth examination of each interface following in a later section.

B. IEEE-488 (1975)

The IEEE-488 interface can be used both to control the operation of the 660 and to input or output data. The IEEE-488 interface may or may not have a bus controller. This must be determined first, since the setting of the hex switches (Section 19-2) followed by a SYStem ReSeT is involved. If no controller is present on the IEEE-488 bus, but use of the interface is desired, non-controller use of the bus may be effected via a switch setting. In this mode, the 660 powers up as a listener

on the bus, making itself a talker when commanded to output data, and reverting to the listener state upon completion of the output. Hence, control of the 660 and data transfer can be accomplished without the use of an IEEE-488 bus controller.

C. RS232-C

The 660 implements EIA RS232-C. To facilitate interconnect to both modems and terminals, the TD, RD connections emulate a modem and the RTS, CTS connections emulate a terminal. Most terminals may be connected with a standard one-to-one cable. Reversing the cable connections to TD, RD gives full terminal emulation. Reversing the cable connections to RTS, CTS gives full modem emulation. The user can select the desired bit rate (from 110 baud to 9600 baud) and the parity (odd, even, or none) via hexadecimal switch settings. As with the IEEE-488 interface, the RS232-C interface can both control the 660 and transfer data into and out of the 660 internal memory.

D. Parallel A/D

The 660 uses 12-bit, 2.5 microsecond conversion time, analog-to-digital converters in the A and B input channels. Data from the converters is provided at the Parallel A/D interface connector in two's complement, fixed point format, with each word to be interpreted as a fraction of the full scale selected by the front panel rotary switches. Alternatively, the internal A/D converter may be effectively replaced by an external source by providing data in the above format to the Parallel A/D connector. This allows the 660 to analyze user-generated digital time domain data.

19.2 Using the Interfaces

A. Selecting Interface Parameters

In order to provide as much flexibility as possible when using the 660 interfaces, many of the interface parameters are user selectable. Some parameters are selected in hardware via a switch setting; some are under program control and can be set using the DEFINE AUX pushbutton in the CALCULATION CONTROL group. The available parameters and the manner in which selection is made are summarized in this section. Additional information about each parameter can be found in the section discussing the interface concepts related to that parameter.

Note, most of the information in the following sections describes the RS232-C and IEEE-488 interfaces. The Parallel A/D interface is discussed separately.

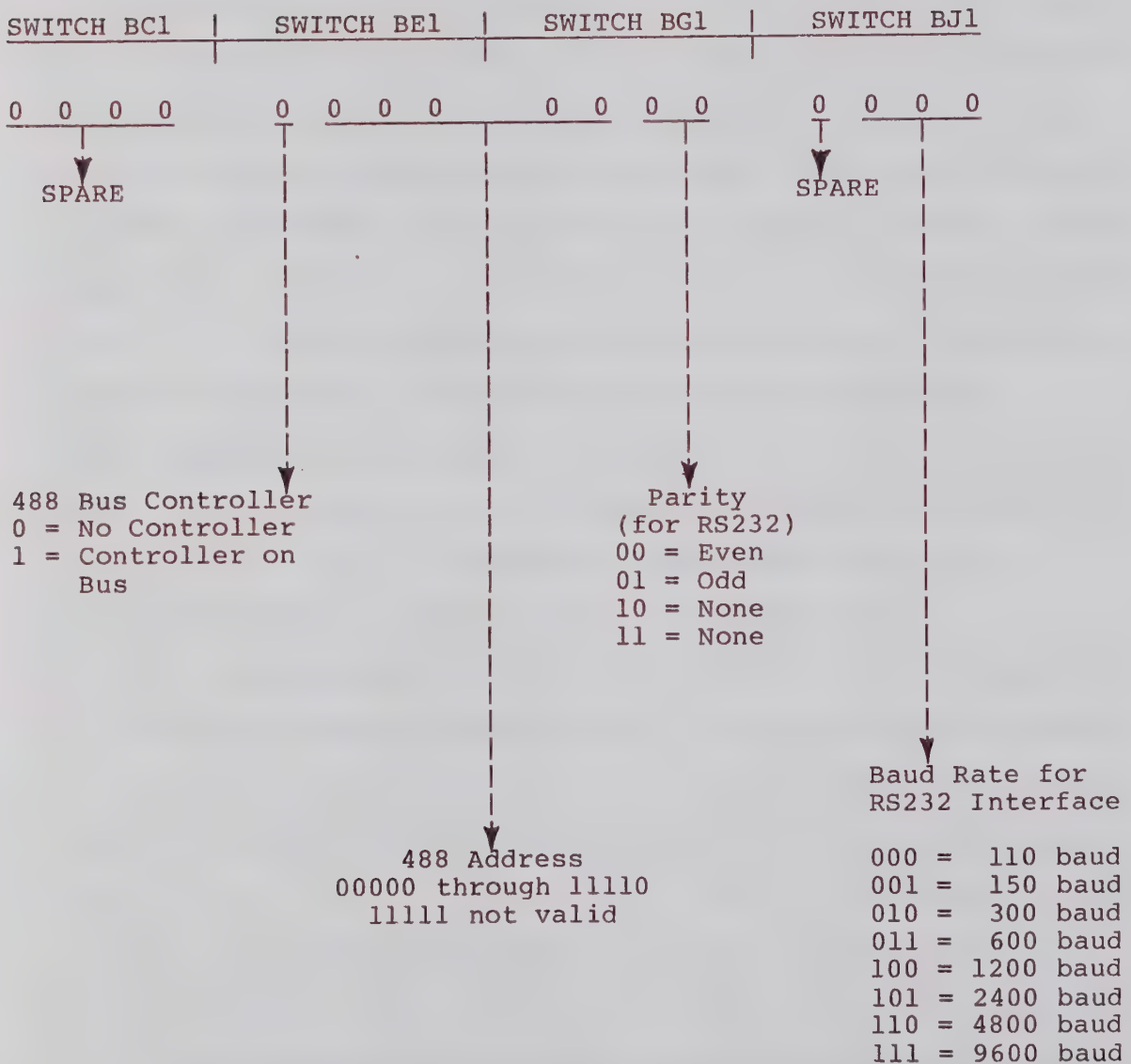
1. Switch Selectable Parameters

The interface parameters which are essential to the operation of the RS232-C and IEEE-488 interfaces are controlled by switch settings. The interface parameters must be matched to the parameters of the interface in use. If the parameters are not matched, errors will occur either in the 660 or the external device.

Figure 19-1 indicates the interface parameters which are switch selectable. These switches are rotary hexadecimal switches and are located on the Executive Board as shown in Figure 19-2. Note, the unusual switch numbering scheme is based on the component locating method used on the Executive Board.

FIGURE 19-1

HEXADECIMAL SWITCH SETTINGS



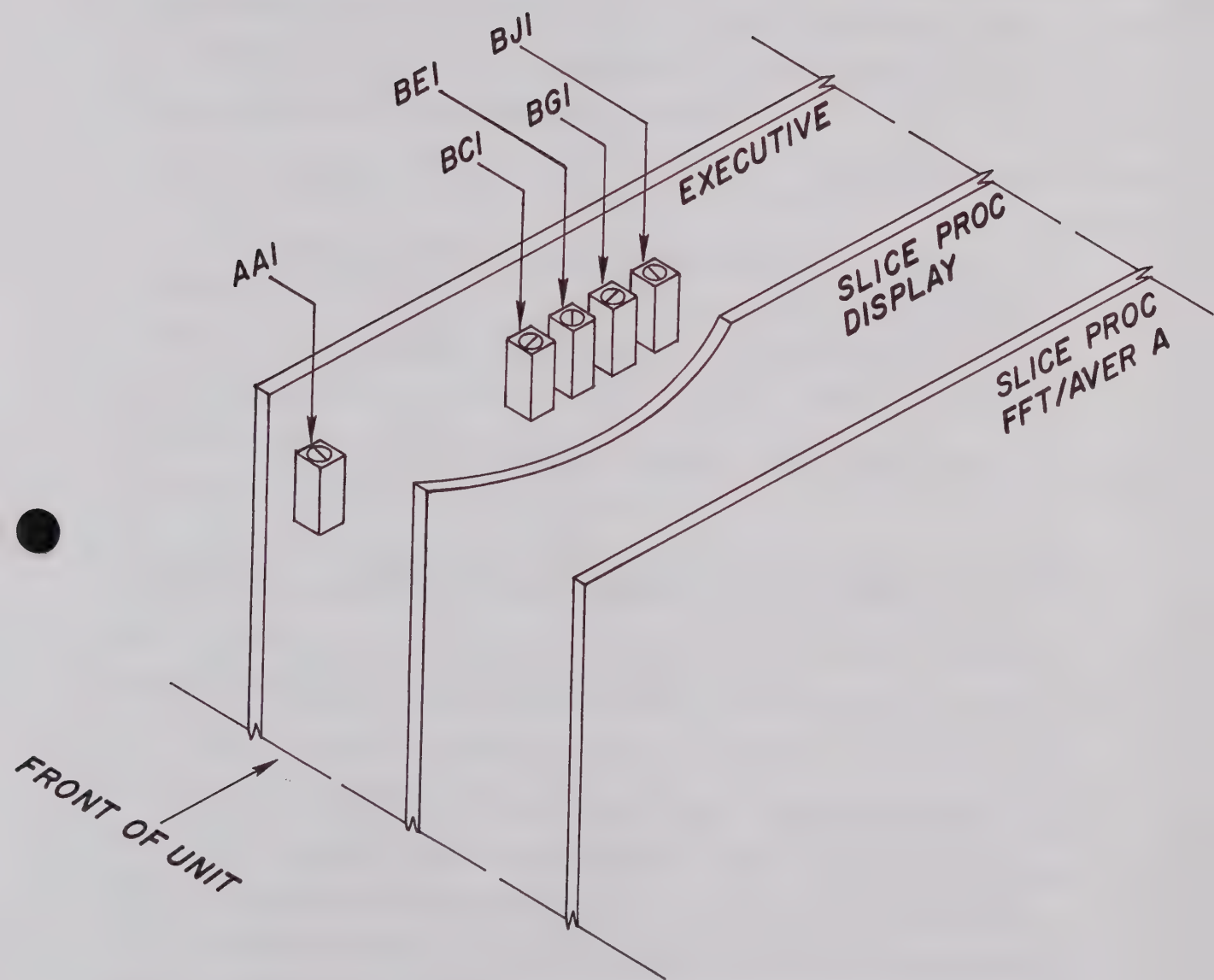


FIGURE 19-2 LOCATION OF SWITCHES ON EXECUTIVE BOARD

For example, switch BC1 is located at Section B, Column C, and Row 1. Each switch controls the value of 4 bits of parameter information. To select the correct switch setting, determine the value of each parameter bit (0 or 1) and add together the weighted value of the bits which are 1. The weights are 8, 4, 2, or 1 as shown in Figure 19-1. The weighted sum equals the setting of the switch except that sums of 10 = A, 11 = B, 12 = C, 13 = D, 14 = E, and 15 = F.

For example, if the following parameters are desired:

- a. 488 Address = 7 = 00111
- b. 488 bus controller on the IEEE-488, and
- c. the RS232-C interface should operate at 600 baud with even parity

then the bit values from Figure 19-1 are as follows:

SPARE	488 CONTROLLER	488 ADDRESS	PARITY	SPARE	BAUD RATE
0000	1	00111	00	0	011

Grouping these bits 4 at a time, since there are 4 bits per switch, gives 0000 1001 1100 and 0011. The weighted sum of these bits is : 0 9 12 3. Since 12 = C, the switch settings are BC1 = 0, BE1 = 9, BG1 = C, and BJ1 = 3.

The parameters selected by the hexadecimal switches are fundamental to the operation of the RS232-C and IEEE-488 interfaces. The switches are interrogated only on power-up

and after the SYS RST (system reset) pushbutton has been depressed. If any switch setting is changed while the 660 is on, the SYS RST pushbutton must be depressed for the desired parameters to be selected. The parameters pertaining to the RS232-C and IEEE-488 interfaces are discussed in the sections describing each interface.

2. DEFine AUXiliary Selectable Parameters

Another group of interface parameters can be selected in conjunction with the DEF AUX pushbutton. The parameters are summarized in Figure 19-3. The general format of a DEF AUX code is a two-digit number (GP). The first digit (G) determines the group or DEF AUX series. The second digit (P) selects a function within that group.

To set any of the functions indicated in Figure 19-3, enter the sequence: GP SET DEF AUX, where GP is the DEF AUX code corresponding to the parameter desired. The 660 will acknowledge the setting of a DEF AUX function by displaying the DEF AUX code followed by the group abbreviation in the entry field shown in Figure 19-3. For example, if the sequence: 51 SET DEF AUX is entered, the entry field will display: 51 OUTT. If the number entered is not a valid DEF AUX code, an error message will be displayed in the entry field. This error message will display the valid range of codes in inverted characters. For example, if the sequence: 37 SET DEF AUX is entered, the entry field will display: "30 > 35" indicating the allowable range of values for the 30 series of DEF AUX.

FIGURE 19-3

SUMMARY OF DEFINE AUXILIARY SERIES

<u>SPECIAL OUTPUT USING AUX BUTTON</u>		<u>ABBR. = AUX0</u>
Function	DEFine AUX	Comments
Rest at cursor mode for analog plotter	00	
134A or 136A Plotter output over RS232-C Interface	01	Default
134A or 136A Plotter output over IEEE-488 Interface	02	For use by the 160 Data Recorder Adapter
Cursor fields output over RS232-C Interface	03	The 50 series of DEFine AUX is used to determine the separators between cursor fields
Cursor fields output over the IEEE-488 Interface	04	

NOTE: LEADING ZERO IS OPTIONAL.

<u>BLOCK SYNC AND REDUNDANCY</u>		<u>ABBR. = REDN</u>
Function	DEFine AUX	Comments
Normal triggering with 50% redundancy	10	Default
Normal triggering with 0% redundancy	11	
Block sync triggering with 50% redundancy	12	
Block sync triggering with 0% redundancy	13	

FIGURE 19-3 (Con't)

SUMMARY OF DEFINE AUXILIARY SERIES

<u>ANNOTATION & GRATICULE</u>		<u>ABBR. = ANGR</u>
Function	DEFine AUX	Comments
All On	20	Default
Graticule Off	21	
Annotation Off	22	Includes cursor fields
Annotation & Graticule Off	23	
Data Off	24	
Data & Graticule Off	25	
Data & Annotation Off	26	
All Off	27	

NOTE: ENTRY FIELD CAN NOT BE TURNED OFF.

<u>I/O FORMAT</u>		<u>ABBR. = I/OF</u>
Function	DEFine AUX	Comments
Decimal ASCII format	30	3 formats dependent on internal format
Decimal ASCII with blank blockfill on output†	31	8-bit integers = 4 characters (0 to 255); 16-bit integers = 8 characters (-32768 to +32767); 3-byte floating point = 12 characters (X.XXX+EE)
Hexadecimal ASCII format	32	2 characters per byte
Hexadecimal ASCII with blank blockfill	33	
Binary Format	34	Default format
Binary Format with null blockfill	35	Block fill byte is nulls instead of blanks
S1 Format (Output Only)	36	For NSC Test Dept. ONLY
S1 Format with S9 at End (Output Only)	37	For NSC Test Dept. ONLY

†THE 660 REQUIRES ALL INPUT TO BE BLOCK FILLED.

FIGURE 19-3 (Con't.)

SUMMARY OF DEFINE AUXILIARY SERIES

SINE WAVE AT CURSOR CONTROL

ABBR. = SINE

Function	DEFine AUX	Comments
Off	40	
Sine Wave At Cursor	41	All functions work with DRT on or off
Pseudo-Random Noise	42	
Periodic Noise	43	

OUTPUT BLOCK TERMINATORS

ABBR. = OUTT

Function	DEFine AUX	Comments
No terminators	50	Terminators are not included in the block size on the output. On input, no terminators are allowed and the setting of the 50 series DEFine AUX is ignored. Terminators can only be applied if the format is ASCII.
EOT after last block	51	
Carriage return after each block	52	
Carriage return after each block plus EOT after the last carriage return	53	However, if the input format is ASCII, an EOT will terminate the input.
Carriage return/line feed after each block	54	Terminators can only be applied if the format is ASCII
Carriage return/line feed after each block plus EOT after last carriage return/line feed	55	Default

SOFTWARE HANDSHAKE FOR OUTPUT OVER RS232-C INTERFACE

ABBR. = HSHR

Function	DEFine AUX	Comments
No handshake required	60	
660 waits for a ready byte (CNTRL/V) before outputting each block	61	61 is the default condition for the 60 series of DEFine AUX

FIGURE 19-3 (Con't.)

SUMMARY OF DEFINE AUXILIARY SERIES

DIAGNOSTICSABBR. = DIAG

Function	DEFine AUX	Comments
Normal	70	Default
For NSC Test Dept. ONLY		Changing this DEF AUX setting could drastically affect the operation of the 660

MODEL 136A DIGITAL PLOTTING
ADAPTER PAGINATIONABBR. = PAGE

Function	DEFine AUX	Comments
No pagination	80	Default
1-9 Pages after Plot	81-89	

TEXT OPTIONABBR. = TEXT

Function	DEFine AUX	Comments
Text Option	90	Default, text off
	91	Line 1 on display
	92	Line 2 on display
	93	Line 3 on display
	94	Line 4 on display
	95	All form lines on display

SINE WAVE AT CURSOR
AMPLITUDEABBR. = AMPL

Function	DEFine AUX	Comments
Amplitudes of all out- puts from Sine Wave at Cursor Option	100-199	Peak Voltage = (N - 100) * 100 mv Default H = 100 ... 1 volt peak

To determine the current state of any DEF AUX selectable parameter, enter the sequence: (G) RECALL DEF AUX where G is the group number associated with the DEF AUX parameter. The 660 entry field will display the current setting of that group followed by the group abbreviation. For example, if the current 30 series of DEF AUX is 34 (I/O format is binary with no blockfill) and the sequence: 3 RECALL DEF AUX is entered, the entry field will display: 34 I/OF.

On power-up, after SYS RST or after entering the sequence: CLEAR PaNeL, the DEF AUX groups are set to the default states indicated for each group in Figure 19-3. A more detailed discussion of the functions selectable via the DEF AUX pushbutton may be found in Figure 19-3.

NOTE: THE SETTINGS OF THE DEF AUX CODES FOR ALL DEF AUX GROUPS AS WELL AS THE FRONT PANEL SETTINGS ARE STORED WHEN THE SEQUENCE: NUMBER (1 THROUGH 9) SET PANEL IS ENTERED. THIS PROVIDES AN EASY METHOD OF SAVING FREQUENTLY DESIRED I/O PARAMETERS.

B. Types of Information

Two types of information can be transferred over the the interfaces to the 660. The first type consists of commands used to control the operation of the 660. The command set allows the user to emulate the front panel via either the RS232-C or the IEEE-488 interface. Certain commands, not available on the front panel, are available to the user when controlling the 660 with an interface, for example, a front panel lock out command.

The second type of information transferrable over the RS232-C or IEEE-488 interface is information from or to one of the 660 internal data buffers. The data buffers allow the user to access data at specific points in the processing flow of the 660.

For example, unprocessed digital time data, and unscaled averaged frequency domain data, can be output or input. Control settings of the 660 can also be output for use by an external device. This enables the user to replicate the front panel settings in future operations. The exact nature and format of each type is covered in Section 19.3, Paragraph B.

C. Controlling the 660

1. Emulating the Front Panel

In the normal operating mode, the user operates the 660 via the front panel. When a button is depressed or a switch position changed, the front panel communicates the user's request to the system executive using a one or two character code in ASCII format. The system executive acts based on the character code received. The character transmission from the front panel to the system executive is internal and transparent to the user.

The front panel is not the sole command input. Additional ports for command characters are the RS232-C and IEEE-488 interfaces. Once the executive receives a command from either the front panel or over an interface, the source of command is retained. The executive performs the actions corresponding to the command code and returns an acknowledge to the source of command. See Figure 19-4.

The code associated with each front panel switch is indicated in Figure 19-5. The code is located in the upper right-hand corner of each pushbutton; the code for each fixed switch and joystick position is shown adjacent to the label for that position.

COMMAND INPUTS TO THE EXECUTIVE

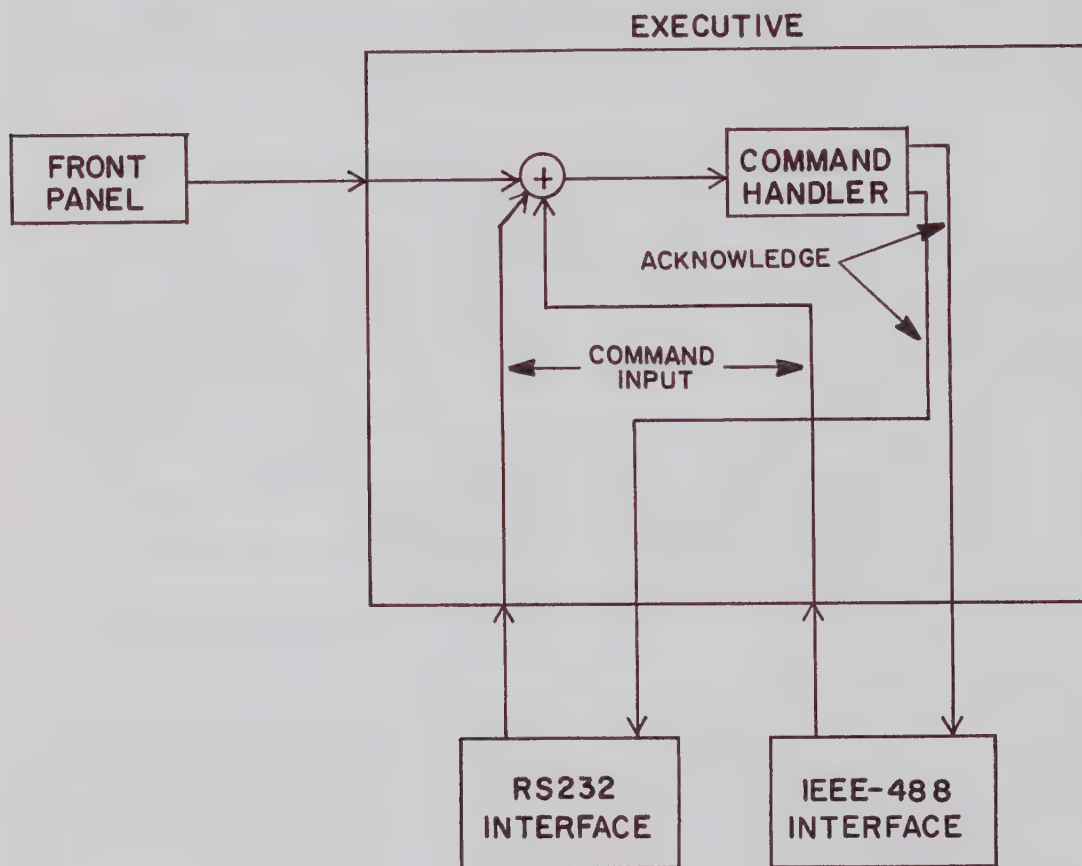


FIGURE 19-4. COMMAND INPUTS TO THE EXECUTIVE

A discussion follows of the commands generated by the pushbuttons and fixed switches on the front panel and the corresponding actions of the system executive upon receiving these commands. Having established the equivalence of commands issued from the front panel with those issued over the RS232-C and IEEE-488 interfaces, any statement concerning a particular pushbutton on the front panel, holds true for command codes issued over the interface.

a. The commands received by the system executive are checked in the same manner regardless of their source. For example, issuing an F2 over an interface while in the CHA 2K FFT mode will cause the error message MUST VIEW A to be displayed in inverted characters in the entry field and, a NAK will be returned if the interface was RS232 or if the interface was IEEE-488, the serial poll register will be updated with NAK status.

b. The command codes associated with pushbuttons astericked in Figure 19-6 complement the state controlled by that pushbutton. When using the interfaces, additional commands are provided for selecting a particular state. See Section 19.2, Paragraph C.2., entitled "Additional Remote Commands."

REMOTE CONTROL COMMANDS

MODE

SIG ENH	Signal Enhancement	MO
CHA 2K (2K CHA FFT) †	2K Channel A FFT	M1
DUAL 1K (1K CHA-B FFT)	1K Channel A-B FFT	M2
CORR	Correlation	M3
PROB	Probability	M4
TEXT	Enter or exit TEXT mode	M5

FUNCTION

INPT TIME (INPUT TIME)	Input Time	J0
AVG TIME	Averaged Time	J1
INST SPEC	Instantaneous Spectrum	J4
RMS SPEC	Averaged RMS Spectrum	J5
PWR SPEC (POWER SPEC)	Averaged Power Spectrum	J6
X SPEC (CROSS SPEC)	Averaged Cross Spectrum	J2
TF	Transfer Function	J3
COH	Coherence Function	JB
IMP RESP (IMPUL RESP)	Impulse Response	J9
TM	Transmissibility	JA
COP	Coherent Output Power	J7
X CORR (CROSS CORR)	Cross Correlation	JD
AUTO CORR	Auto Correlation	JC
CDF (CUM DIST)	Cumulative Distribution Function	K1
PDF (PROB DEN)	Probability Density Function	K0
TEXT 2	Text Line 2	K9
TEXT 3	Text Line 3	KA
TEXT 4	Text Line 4	KC

AVERAGE

SUM	Summation Averaging	V0
START	Start	V8
DIFF	Difference Averaging	V1
STOP	Stop	V9
EX (EXP)	Exponential Averaging	V2
CONT	Continue	VA
PEAK	Peak Detect Averaging	V3
SWEEP	Sweep Averaging	V4
TRAN (TRANS)	Transient Averaging	V5

DISPLAYCH

A	Channel A	F1
B	Channel B	F2
A B	Channel A and B	F3

† 660 Pushbutton abbreviations follow in ().

FIGURE 19-6 (Con't.)

REMOTE CONTROL COMMANDS

DISPLAY (Con't.)FORMAT

NYQ	Nyquist	F7
REAL	Real	F4
IMAG	Imaginary	F5
R I	Real and Imaginary	F6
MAG	Magnitude	F8
Ø (PHASE)	Phase	F9
Ø MAG (PHASE MAG)	Phase and Magnitude	FA

MEMORY

STO (STORE) *	Store	E0
COMP *	Compare	E2
RCL (RECALL) *	Recall	E1
EQL (EQL TF/TM) *	Equalize Transfer Function or Transmissibility	E3

AMPLITUDE UNITS (CURSOR READS)

dB/LIN *	Complement Current State	U0
V/EU *	Complement Current State	U1
ABS/REL *	Complement Current State	U2
PER Hz *	Complement Current State	U3

CURSOR POSITION

LEFT	Small Step	I0
RIGHT	Small Step	I1
LEFT	Large Step	I8
RIGHT	Large Step	I9

CURSOR TYPE

HARMONIC	H3
SINGLE	H1
OFF	H0

GAIN

Upper Increase	I2
Upper Decrease	I3
Lower Increase	I4
Lower Decrease	I5

*Complements current state. Additional commands exist to set or reset state.

FIGURE 19-6 (Con't.)

REMOTE CONTROL COMMANDS

FREQ READS

Hz		H4
CPM		H5
ORDERS		H6

SCALES

AMPL LOG/LIN *	Vertical (Amplitude) Axis	
	Logarithmic/Linear	G0
FREQ LOG/LIN *	Horizontal (Frequency) Axis	
	Logarithmic/Linear	G1

OUTPUT TYPE

PLOT *		00
PLOT CAL (PLOT SET-UP) *		01
AUX *		02
CRT ONLY		03

CALCULATION CONTROL

+		+
7		7
4		4
1		1
0		0
-		-
8		8
5		5
2		2
.		.
EXP	Exponent	X
9		9
6		6
3		3
SET STORE		S
RECALL		R
CLEAR		Z
AVG N	Number of Averages	W0
PNL (PANEL)	Panel Manipulation	W1
$\int dt$	Integrate	W2
COH BLNK	Coherence Blanking	W3
KEY XPND or XPND	Key Expand or Expand	W4

*Complements current state. Additional commands exist to set or reset state.

FIGURE 19-6 (Con't.)
REMOTE CONTROL COMMANDS

CALCULATION CONTROL (Con't.)

DLY T → A (DELAY T → A)	Delay from Trigger to Channel A	W5
CUR LOC	Cursor Location	W6
d/dt	Differentiate	W7
PLOT RATE	X-Y Plotter Speed Control	W8
CUR XPND or XPND WIDTH	Cursor Expand or Expand Width	W9
DLY A → B (DELAY A → B)	Delay from Channel A to Channel B	Y0
RMS 1 → 2	RMS Value Between Cursor 1 Location and Cursor 2 Location	Y1
DEF AUX (DEFINE AUX)	Define Auxiliary Codes	Y2
DSPL dB	Number of dB on Vertical Axis	Y3
DISK		Y4
LIN	Linear Reference	Y5
dB	Logarithmic Reference	Y6
V/EU	Volts per Engineering Unit	Y7
FREQ REF	Frequency Reference	Y8
ORD REF (ORDER REF)	Order Reference	Y9

INPUT CHANNEL A

TEST		C3
AC	AC Coupled	C1
DC	DC Coupled	C0
INVERT (INV)	Invert Data	C5
NORMAL (NOR)	Normal Data	C4
ZERO	Zero Data	C6
MAX AMPLITUDE		
.1		A0
.2		A1
.5		A2
1		A3
2		A4
5		A5
10		A6
20		A7

INPUT CHANNEL B

TEST		D3
AC	AC Coupled	D1
DC	DC Coupled	D0

FIGURE 19-6 (Con't.)

REMOTE CONTROL COMMANDS

INPUT CHANNEL B (Con't.)

INVERT (INV)	Invert Data	D5
NORMAL (NOR)	Normal Data	D4
ZERO	Zero Data	D6

MAX AMPLITUDE

.1	B0
.2	B1
.5	B2
1	B3
2	B4
5	B5
10	B6
20	B7

FREQUENCY RANGE

1 Hz	Q0
2 Hz	Q1
5 Hz	Q2
10 Hz	Q3
20 Hz	Q4
50 Hz	Q5
100 Hz	Q6
200 Hz	Q7
500 Hz	Q8
1 KHz	Q9
2 KHz	QA
5 KHz	QB
10 KHz	QC
20 KHz	QD
50 KHz	QE
100 KHz	QF

FREQ	Internal Sampling	N0
ORDERS	External Sampling	N1

CAPTURE CONTROL

DATA TYPE		
CONT	Continuous (Weighted)	T0
TRAN (TRANS)	Transient (Unweighted)	T1

FIGURE 19-6 (Con't.)

REMOTE CONTROL COMMANDS

CAPTURE CONTROL (Con't.)

TRIG SOURCE		
CH A		T2
CH B		T3
HOLD/REL *	Complement Hold Release State	!
ARM	Arm the Input Buffer	#
TRIG LEVEL		
+ 1/2	Of Full Scale	L0
+ 1/4	Of Full Scale	L1
+ 1/8	Of Full Scale	L2
+ 1/16	Of Full Scale	L3
– 1/16	Of Full Scale	L7
– 1/8	Of Full Scale	L6
– 1/4	Of Full Scale	L5
– 1/2	Of Full Scale	L4
SYS RESET	System Reset	'DC3' : (CNTRL/S)

TEXT ENTRY OPTION

ABC	Entry A, B, or C	P0
DEF	Entry D, E, or F	P1
GHI	Entry G, H, or I	P2
JKL	Entry J, K, or L	P3
MNO	Entry M, N, or O	P4
PQR	Entry P, Q, or R	P5
STU	Entry S, T, or U	P6
VWX	Entry V, W, or X	P7
YZd	Entry Y, Z, or d	P8
(<%	Entry (, < , or %	P9
) > ,	Entry), > , or ,	PA
'# :	Entry ', #, or :	PB
RUB	Delete character, blank rest of line, or enter NULL	PC
INS	Insert on or off	PD
	Second character select on or off	PE
	Third character select on or off	PF

*Complements current state. Additional commands exist to set or rest state.

c. The commands associated with each fixed switch, (those switches which are not pushbuttons and not one of the three joysticks), are issued by the front panel only when the switch position changes. This allows the code for a desired switch setting to be sent using an interface, without the front panel overriding the information with a current switch setting. However, if a switch setting on the front panel is changed, the new position will override the setting commanded by an interface. For example, if the FREQUENCY RANGE rotary selector is set to 200 Hz and the code QE (50,000 Hz) is issued over an interface, the 660 will enter the 50,000 Hz range. If the FREQUENCY RANGE rotary selector is then set to 100 Hz, the 660 will enter that range. This front panel override of the setting issued over an interface can be prevented by effecting the front panel lock out feature, see Section 19.2, Paragraph C.2, entitled "Additional Remote Commands."

d. There are three joysticks on the front panel of the 660, namely, GAIN--UPPER OR SINGLE, GAIN LOWER, and CURSOR POSITION--LEFT or RIGHT. Each is actually a three-position joystick with a neutral center position. The term neutral means that no action is taken by the 660 when the joystick is in the the neutral center position. When a joystick is moved to either extreme, the appropriate command is issued. The joysticks differ from the fixed switches in that they incorporate a timer which reissues the current joystick position command if the joystick is not returned to the neutral position within a prescribed delay period. The CURSOR POSITION joystick has the additional

distinction that when the stick is first moved, the cursor moves a single cursor cell position in the direction indicated. However, when the timer reissues the cursor movement command, the larger stepsize command is used.

Issuing the codes associated with the joysticks from an interface causes one step to be taken in the appropriate direction. If more than one step is desired, the command must be reissued a number of times until the appropriate gain or cursor position is achieved. In the case of the cursor joystick, both stepsize commands for each direction are available to the interfaces.

C 2. Additional Remote Commands

In addition to the commands available on the 660 front panel, the interfaces can issue commands which provide important additional functions and useful features. These extra commands are listed separately in Figure 19-7 as additional remote control operations. The command codes are also shown on the diagram of the 660 front panel, Figure 19-5.

The definition and use of these commands are as follows:

a. Setting Complement Functions - The front panel contains pushbuttons which complement the states controlled by those pushbuttons. Since it may be difficult to ascertain the current state when remotely controlling the 660, additional commands are provided for setting the desired state regardless of the current state. These commands are grouped according to the section of the front panel on which they appear, i.e. DISPLAY, AMPLITUDE UNITS, SCALES, and CAPTURE CONTROL. For example, in the AMPLITUDE UNITS section of the front panel, depressing the dB/LIN button, or is-

FIGURE 19-7

ADDITIONAL REMOTE COMMANDS

<u>SECTION and COMMAND</u>	<u>CODE</u>
<u>DISPLAY Section</u>	
SET Recall	E4
SET Compare	E5
SET Equalize	E6
CLEAR Recall, Compare, and Equalize	E7
<u>AMPLITUDE UNITS Section</u>	
SET dB/LIN to dB	U4
SET V/EU to V	U5
SET ABS/REL to ABS	U6
SET PER Hz 'ON'	U7
RESET dB/LIN to LIN	U8
RESET V/EU to EU	U9
RESET ABS/REL to REL	UA
RESET PER Hz to 'OFF'	UB
<u>OUTPUT TYPE Section</u>	
SET PLOT to OFF	04
SET PLOT CAL to OFF	05
SET AUX to OFF	06
CRT ONLY	07
SET PLOT to ON	08
SET PLOT CAL to ON	09
SET AUX to ON	0A
CRT ONLY	0B
<u>SCALES Section</u>	
SET AMPL LOG/LIN to LOG	G2
SET FREQ LOG/LIN to LOG	G3
RESET AMPL LOG/LIN	G4
RESET FREQ LOG/LIN	G5
<u>CAPTURE CONTROL Section</u>	
Force Input Buffer to HOLD	\$
Release Input Buffer	"

FIGURE 19-7 (Con't.)

ADDITIONAL REMOTE COMMANDS

<u>SECTION and COMMAND</u>	<u>CODE</u>
<u>ADDITIONAL COMMANDS Section</u>	
External I/O Blocksize Control	WA
IEEE-488 SRQ Mask	WB
External I/O Initiate Commands	
Input to buffer n from RS232-C Interface	>n
Output from n over RS232-C Interface	=n
Input to n from IEEE-488 Interface	@n
Output from n over IEEE-488 Interface	?n
Lock out Front Panel Operation ¹	'DC1':(CNTRL/Q)
Enable Front Panel Operation ¹	'DC4':(CNTRL/T)
Enter Entry Field ALPHA Mode ¹	'RS' : (CNTRL/^)
Exit Entry Field ALPHA Mode ¹	'FS' : (CNTRL/\)
Invert Characters in Entry Field ¹	'BEL':(CNTRL/G)
Output Status Byte over IEEE-488 Interface ¹	'BS' : (CNTRL/H)
Output Status Byte over RS232-C Interface ¹	'HT' : (CNTRL/I)
Used Internally	(CNTRL/A through CNTRL/F)
	CARRIAGE RETURN
	LINE FEED

¹The codes between quotes are the mnemonics for single ASCII characters generated by the keystrokes between the parentheses. 'CNTRL' means to hold the CNTRL key while depressing the character following the slash, for example, CNTRL/S means hold CNTRL while pressing S.

suings the code U0 from an interface, causes the current state to be complemented. If the code U4 is issued from an interface, the cursor reading will be in dB whether or not the current reading is in dB.

b. External I/O Blocksize Control - The blocksize is an important parameter when inputting or outputting a data buffer. The blocksize is the number of bytes the 660 considers a group during input or output. On output, the 660 uses the blocksize parameter to determine the number of fill characters to add if blockfill is desired (30 series of DEF AUX) and, if the RS232-C interface is being used, when to wait for the software handshake before continuing the output (60 series of DEF AUX). When data is input to the 660, the predetermined blocksize must be strictly observed. See I/O Format Section for a detailed account of block size.

The blocksize can be set to any number of bytes from 1 to 2048, inclusive. The blocksize is set by issuing over an interface the command sequence: number SET BLOCKSIZE (SWA). For example, to set the blocksize to 1024 bytes, the following characters should be entered over the interface: 1024SWA, where 1024 is the blocksize desired, S is the code for the SET push-button, and WA is the code for blocksize control.

When the blocksize has been set, the entry field of the 660 will display: 1024 IOBS, indicating the I/O

blocksize is now set to 1024 bytes. The current setting of the blocksize can be interrogated at any time by issuing over an interface the command: RECALL BLOCKSIZE (RWA). The current blocksize, followed by the letters IOBS, will be displayed in the entry field.

On power-up and after a system reset, the blocksize is set to 72 bytes. The blocksize can be returned to the default state by issuing over an interface the command: CLEAR BLOCKSIZE (ZWA). The default blocksize is then displayed in the entry field.

The choice of blocksize is usually determined by the requirements of the device receiving data from, or sending data to, the 660. When inputting data to the 660, maximum transfer rates will be achieved if blocksizes of 1024 or less are used. WB, for an explanation of the SRQ mask, see the appendix, "Setting the 488 Environment".

c. External I/O Initiate Commands - These commands allow the user to start a transfer of data to or from any of the 660 internal data buffers over either the RS232-C or the IEEE-488 interface. There are 16 data buffers numbered 0 through F, see Section 19-3, any of which can input or output. The current blocksize and DEFINE AUX settable parameters are used for the data transfer. For example, to output the

buffer containing the front panel settings (buffer 0) over the 488 interface, the desired blocksize and DEF AUX settings should be entered. When the receiver is ready to accept the data, the command: ?0 should be entered over an interface. Additional information about data transfers, I/O parameters, and available data buffers can be found in the section entitled, "Accessing Data," Section 19-3.

d. Front Panel Lock Out - When controlling the 660 with an interface, commands from the front panel will also be honored. Undesired results will be obtained, for example, if parameters for a data transfer are being set from an interface while, at the same time, another user changes the front panel settings. This is especially true if the 660 and the device remotely controlling the 660 are not in the same room. The conflicts between remote commands and front panel commands can be prevented by issuing the lock out front panel operation command(DC1 or control Q) from an interface. When this command is received by the system executive, all commands originating from the front panel are ignored. Hence, all the front panel pushbuttons and switches are locked out. In addition, to indicate that the front panel cannot be used, the REMOTE CONTROL led is on.

One front panel button that can not be locked out is the "system reset" button. Pressing SYS RST button, even when the REMOTE CONTROL light is on, will always return the 660 to the wake-up state (and erase volatile memory).

After the lock out command has been issued, front panel operation can be reinstated by issuing the enable front panel operation (command DC4 or control T). When this command is received by the 660, three events occur:

1. The system executive will be instructed not to ignore front panel commands, thus unlocking the front panel,
2. The remote control LED will be extinguished, and
3. The current setting of all front panel fixed switches will be interrogated since their positions could have been changed while the front panel was locked out.

e. Entry Field Alpha Mode - Character strings longer than 14 characters can be displayed in the 660 entry field using the alpha mode of the interfaces. Normally, any characters received from an interface are interpreted as command codes. If the entry field alpha mode command RS (control /) is issued, however, all subsequent characters received from an interface will be scrolled into the entry field. As each character is received by the 660, the 14 characters in the entry field shift one position to the left.

The new character is placed in the right-most position, and the character which was formerly in the left-most position is lost.

To exit the alpha mode, two commands are available. The exit entry field alpha mode command FS (control \) , causes all subsequent characters received over the interfaces to be interpreted as command codes. The BEL (control G) command has the same effect as the exit alpha mode command except that, in addition, the characters in the entry field are inverted.

The alpha mode is a special mode available to the interfaces and several limitations on the alpha mode should be noted:

1. If the front panel is not locked out and if any pushbutton is depressed or switch position is changed, the alpha mode is exited immediately and the command from the front panel is honored.
2. While in the alpha mode, any non-printing character will still be interpreted as a command, and no shifting of the entry field will result. The alpha mode will still be in effect unless the command generates an error message. If an error message overwrites the entry field, the character string may be restored by issuing one CLEAR command (the character Z). The alpha mode can now be re-entered and the character string completed. For example, if while in the alpha mode, a DC1 or (control Q) is received, the front panel will be locked out, but the character string can continue. If an EM (control Y) is received, the 660 will exit the alpha mode and display OPTION N/A in the entry field. Issuing the commands Z RS (control ^) will enable the user to continue entering the character string.

3. No backspace command exists for the alpha mode. If an error is made, the alpha mode must be exited, and the entry field cleared. The alpha mode can then be re-entered and characters scrolled into the entry field.
4. A dollar sign (\$) is displayed as a lower case d. No character exists which will cause a dollar sign to be displayed.

f. Invert Characters in Entry Field - As mentioned in the previous section, a control G causes the 660 to exit the alpha mode and invert the characters in the entry field. In addition, a BEL (control G) causes the characters in the entry field to invert whether or not the 660 is currently in the alpha mode. Hence, any message placed in the entry field by the 660, as well as user generated messages, can be inverted at any time. Once dark characters on a light background are displayed, light characters on a dark background can only be achieved by scrolling non-inverted characters into the entry field.

g. Output Status Byte - For the convenience of the user, the 660 groups some information which might be required in into one 8-bit byte. This byte is called the 660 status byte. Each bit of this byte is assigned a meaning, as shown in Figure 19-8. Each bit has the same meaning as the corresponding LED on the front panel. Thus, the averager on bit corresponds to the LED on the START button and the HOLD, ARM, and PLOT bits correspond to the LEDs on the HOLD, ARM, and PLOT pushbuttons, respectively.

660 STATUS BYTE

OVERLOAD	INTERNAL USE	PLOT ON	HOLD	ARM	INTERNAL USE	INTERNAL USE	AVERAGER ON
7	6	5	4	3	2	1	0

OUTPUT FORMAT DETERMINED BY 30 SERIES DEFINE AUX
TERMINATORS SPECIFIED BY 50 SERIES DEFINE AUX ARE USED

FIGURE 19-8

The overload status bit is turned on whenever an overload on either Channel A or Channel B occurs. Once this bit is on, it will not be turned off, even if the overload light goes out. The overload bit is cleared only upon starting an average. Hence, an average can be started by remote control and after the average is complete, the top bit of the status byte can be examined to determine if an overload occurred at any time during the averaging process.

Three formats are available for examining the status byte, Binary, Hexadecimal ASCII, and Decimal ASCII. These are the same three formats which can be used to output or input data, see Section 19.3, "Accessing Data." The format used is determined by the current setting of the 30 series DEF AUX. Since blocksize is not used when outputting the status byte, blockfill specifications are irrelevant. If Binary format is used (DEF AUX 34 or 35), the status byte is copied to the interface as is.

If Hexadecimal ASCII format is used (DEF AUX 32 or 33), two ASCII characters representing the hexadecimal equivalent of the status byte are sent over the interface. For example, if the bits in the status byte are 1010 0001 the 2 characters "A1" will be output. Decimal ASCII format (DEF AUX 30 or 31) will cause the status byte to be converted to decimal and the ASCII decimal digits will be output in a blank-filled

field of 4 characters. Thus, if the status byte is 10100001* the 4 characters 'ø168' (where ø = blank) will output. If the format used is ASCII hexadecimal or decimal, the terminators specified by the 50 series of DEF AUX are added after the status byte. Additional information on number conversion and data formatting is given in "Accessing Data," Section 19-3.

The bits in the status byte do not change at exactly the same time as the corresponding event occurs, but rather the byte is updated when the LED is updated. Care should be taken when reading the status byte while the 660 is changing state. For example, if one average is requested, 1 SET AVG N (1SW0) and the averager is started (V8), it is possible for the averager to complete before the LED can be lit. Therefore, the status words averager on bit will not be set to 1. To circumvent this the user may issue a HOLD, then START AVG, then RELEASE. It is assured that the AVG ON bit will be 1, then go to 0 at the end of the average.

The overload status will only be updated if another event occurs, such as a new average, or a switch closure. If the overload bit must be updated, such as when remotely setting the gain controls, a SOH (control A) should be issued prior to each output of the status byte. The SOH (control A) causes the 660 status byte to be updated with the current status.

3. Acknowledging Commands

Each byte of a command sent to the 660 is acknowledged.

The acknowledgment indicates:

1. The byte has been accepted and the next byte of the command string can be transmitted, and
2. The type of acknowledgment sent by the 660 indicates whether the command received was valid or invalid.

*(1010 0001 = 128 + 32 + 1 = 168)

The acknowledgment process on the IEEE-488 interface is different from the process on the RS232-C interface. Over the RS232-C, an ACK byte (control F) is output on the RS232-C interface for each command byte entered. The ACK byte indicates that the 660 is ready for another command character to be entered and the character was a valid command. In the case of two character commands, an ACK is sent for each character of the command. An ACK byte does not indicate that the command has been performed, rather, the character was acceptable in the current context. When a character is received by the 660, validity is determined. If the command is valid, the function requested by the command is initiated and an ACK byte is sent. If the character received is not a valid command, an error message is generated in the entry field and a NAK byte (control U) is output instead of an ACK. A NAK indicates that an invalid command was received and the 660 is ready to receive the next command. For each character sent, an ACK or a NAK byte is output.

Both the ACK and NAK characters are non-printing characters. If a terminal is being used to enter commands remotely, it is unnecessary to view the ACK and NAK bytes since the 660 can generally respond to commands faster than the command can be typed. The entry field provides visual feedback that the command has been performed. If a programmable device is controlling the 660, it is essential that no additional command be entered until an ACK or NAK corresponding to the previous command is issued. If this procedure is not followed, command characters will be lost,

and undesired actions may be taken by the 660 due to command characters being taken out of context.

When using the IEEE-488 interface, normally a different acknowledgment process is used. The acknowledgment-indication that a character has been received and that the next character can be sent is provided separately in the hardware of the IEEE-488 interface. When the NDAC (Not Data Accepted) line is released (allowed to float high) by the 660, a byte has been accepted from the bus. When the 660 releases the NRFD (Not Ready for Data) line, the 660 is ready for the next byte to be sent. Hence, when a character is sent over the IEEE-488 interface, the 660 'holds off' the NRFD handshake until it is ready to receive the next byte. The IEEE-488 handshake is then 'released' and the next character can be sent.

If an invalid command is received, the 660 still releases the handshake so that the next character can be sent. If service requests are being issued, the service request line (SRQ) of the IEEE-488 interface may be asserted to indicate to the IEEE-488 bus controller that an invalid command was received by the 660. See Section 19-4. Thus on the IEEE-488 interface, the equivalent of an ACK is releasing the IEEE-488 handshake and the NAK equivalent is issuing a service request and then releasing the handshake. The service request is cleared when the controller performs a serial poll, thus getting the 660 serial poll status byte, which will indicate the NAK. If there is no controller on the bus or if SRQ's are not enabled no service request is issued. See Section 19-4, Operation Without a 488 Bus Controller.

Each character sent over an interface generates an ACK or NAK equivalent. The exception to the ACK/NAK rule is the I/O input initiate command group and the control V handshake. In addition to issuing an ACK after each character of these commands is received, the 660 also issues an ACK or a NAK after the data transfer is complete to indicate whether or not the transfer was successful. If any error occurred during the transfer, a NAK will be issued. Data transfer errors are discussed in the "Accessing Data Section" which immediately follows.

19.3 Accessing Data

The external I/O initiate commands provide the means of accessing the 660 data buffers as discussed in "Controlling the 660," Section 19.2. The contents of the data buffers, external data formats, and other data related interface considerations are discussed in this section. While the data buffers represent the majority of the information available to the user, other supplemental data is output using the AUX and the DISK pushbuttons. This supplemental data is discussed separately at the end of this section.

A. Data Buffers Available

The data which can be output from or input to the 660 is summarized in Figure 19-9. The data is grouped into data buffers, each of which is assigned a number. This number is used as the second character for the external I/O initiate commands, see Section 19.2, "Controlling the 660." The contents of each data buffer is described in this section.

1. Front Panel Settings (Buffer 0)

All information related to the current set-up of the 660 is contained in buffer 0 (ZERO). Figure 19-10 lists the contents of each byte or group of bytes in this buffer. The numbers indicating the contents of a byte are shown as two hexadecimal digits.

FIGURE 19-9

DATA BUFFERS AVAILABLE

BUFFER NUMBER	DATA AVAILABLE	INTERNAL FORMAT	LENGTH IN BYTES	COMMENTS
0	Front Panel Settings	8-Bit Bytes	111	
1	Nonvolatile	8-Bit Bytes	1024	Cursors 1 through 9 and panels 1 through 9.
2	Not Assigned			
3	Not Assigned			
4	First Averager Buffer	3-Byte Floating Point Numbers Except 16-Bit Integers if in Probability Mode	1539	The data in the averager buffers depends on the current mode. The buffers contain magnitude of A, coherent component of the cross-spectrum, and magnitude of B in the 1K FFT Mode.
5	Second Averager Buffer			
6	Third Averager Buffer			
7	Fourth Averager Buffer			
8	First Display Memory Buffer	Same as Averager Buffers	1539	
9	Second Display Memory Buffer	Same as Averager Buffers	1539	
A	Display Memory Status	8-Bit Bytes	132	Needed to correctly interpret display memory buffers.
B	Text Character Strings and Control	8-Bit Bytes	216	Position and contents of text fields when displayed.
C,D	Not Assigned			
E	Averager Status	8-Bit Bytes	11	Needed to correctly interpret averager buffers.
F	General Block	8-Bit Bytes	User Variable	Enables user to access any portion of main memory.

NOTE: The front panel of the 660 is locked out during the transfer of any buffer except buffers 2, 3, and F.

FIGURE 19-10

CONTENTS OF DATA BUFFER 0

OFFSET FROM FIRST BYTE	NAME	LENGTH (BYTES)	DESCRIPTION
0000	SSCURT	1	CURSOR TYPE 00 = OFF 01 = SINGLE 02 = HARMONIC
0001	SSFRQR	1	FREQUENCY READS 00 = HZ 01 = CPM 02 = ORDERS
0002	SSAADT	1	CHANNEL A AC/DC/TEST BIT 1 = 0 = NORMAL INPUT BIT 1 = 1 = TEST INPUT BIT 0 = 0 = DC COUPLED BIT 0 = 1 = AC COUPLED
0003	SSAINZ	1	CHANNEL A NORMAL/INVERT/ZERO 00 = NORMAL 01 = INVERT 02 = ZERO
0004	SSAAMP	1	CHANNEL A INPUT AMPLITUDE 00 = 0.1 01 = 0.2 02 = 0.5 03 = 1.0 04 = 2.0 05 = 5.0 06 = 10.0 07 = 20.0
0005	SSBADT	1	CHANNEL B AC/DC/TEST SAME CODING AS CHANNEL A

FIGURE 19-10 (Con't.)

CONTENTS OF DATA BUFFER 0

OFFSET FROM FIRST BYTE	NAME	LENGTH (BYTES)	DESCRIPTION
0006	SSBINZ	1	CHANNEL B NORMAL/INVERT/ZERO SAME CODING AS CHANNEL A
0007	SSBAMP	1	CHANNEL B INPUT AMPLITUDE SAME CODING AS CHANNEL A
0008	SSFROR	1	FREQUENCY/ORDERS 00 = FREQUENCY 01 = ORDERS
0009	SSFREQ	1	FREQUENCY RANGE 00 = 1 HZ 01 = 2 HZ 02 = 5 HZ 03 = 10 HZ 04 = 20 HZ 05 = 50 HZ 06 = 100 HZ 07 = 200 HZ 08 = 500 HZ 09 = 1K HZ 0A = 2K HZ 0B = 5K HZ 0C = 10K HZ 0D = 20K HZ 0E = 50K HZ 0F = 100K HZ
0010	SSTRGS	1	TRIGGER SOURCE 00 = CHANNEL A 01 = CHANNEL B

FIGURE 19-10 (Con't.)

CONTENTS OF DATA BUFFER 0

OFFSET FROM FIRST BYTE	NAME	LENGTH (BYTES)	DESCRIPTION
0011	SSTRGL	1	TRIGGER LEVEL 00 = +1/2 01 = +1/4 02 = +1/8 03 = +1/16 04 = -1/2 05 = -1/4 06 = -1/8 07 = -1/16
0012	STMODE	1	PROCESSING MODE 00 = MODE 0 = SIG ENH 01 = MODE 1 = 2K FFT 02 = MODE 2 = 1K FFT 03 = MODE 3 = CORR 04 = MODE 4 = PROB 05 = MODE 5 = TEXT MODE* 06 = MODE 6 = SPARE 07 = MODE 7 = SPARE 08 THRU FF INVALID
0013	STFUNC	1	FUNCTION SELECTED 00=FUNCTION 0=INPUT TIME 01=FUNCTION 1=AVG TIME 02=FUNCTION 2=CROSS SPEC 03=FUNCTION 3=TF (TRANSFER FUNCTION) 04=FUNCTION 4=INST SPEC 05=FUNCTION 5=RMS SPEC 06=FUNCTION 6=POWER SPEC 07=FUNCTION 7=COP 08=FUNCTION 8=SPARE 09=FUNCTION 9=IMPL RESP 0A=FUNCTION 10=TM (TRANSMIS- SIBILITY) 0B=FUNCTION 11=COH 0C=FUNCTION 12=AUTO CORR

*Text Mode is a mode modifier; it will not be indicated as a separate mode, however, no mode 5 will exist, since logically text occupies this position.

FIGURE 19-10 (Con't.)

CONTENTS OF DATA BUFFER 0

OFFSET FROM FIRST BYTE	NAME	LENGTH (BYTES)	DESCRIPTION
0013 (Con't.)			0D=FUNCTION 13=CROSS CORR 0E=FUNCTION 14=SPARE 0F=FUNCTION 15=SPARE 10=FUNCTION 16=PROB DEN 11=FUNCTION 17=CUM DIST 12=FUNCTION 18=SPARE 13=FUNCTION 19=SPARE 14 THRU FF INVALID
0014	STCHNN	1	DISPLAY CHANNEL 00 = INVALID 01 = CHANNEL A 02 = CHANNEL B 03 = CHANNEL A & B 04 = CROSS PROPERTIES
0015	STFRMT	1	DISPLAY FORMAT 00 = REAL 01 = IMAG 02 = REAL/IMAG 03 = NYQ 04 = MAG 05 = PHASE 06 = PHASE/MAG 07 = SPARE
0016	STAVGM	1	AVERAGER MODE X0 = SUM X1 = DIFF X2 = EXPO X3 = PEAK X4 = SWEEP* X5 = SPARE X6 = SPARE 0X = CONTINUOUS AVERAGING 8X = TRANSIENT AVERAGING* *84 = NOT VALID (TRANSIENT SWEEP)

FIGURE 19-10 (Con't.)

CONTENTS OF DATA BUFFER 0

OFFSET FROM FIRST BYTE	NAME	LENGTH (BYTES)	DESCRIPTION
0017	STDMST	1	DISPLAY MEMORY STATUS 00 = NOT RECALL, OR COMP, OR EQL TF/TM 01 = RECALL (Bit 0 = 1) 02 = COMP (Bit 1 = 1) 03 = INVALID 04 = EQL TF/TM (Bit 2 = 1) 05 THRU FF INVALID
0018	STOUTT	1	OUTPUT TYPE BIT 0=0 PLOT SETUP =1 BIT 1=0 PLOT =1 BIT 2=0 AUX =1 BIT 4, BIT 3 = 0,0 POSITION 1 OF PLOT 0,1 POSITION 2 SETUP 1,0 POSITION 3 1,1 POSITION 4
0019	STSCLS	1	DISPLAY SCALES BIT 0=0 = LIN VERT BIT 0=1 = LOG VERT BIT 1=0 = LIN HORZ BIT 1=1 = LOG HORZ BITS 7 to 2 NOT USED
0020	STCRDS	1	CURSOR READS FLAGS BIT 0=0 = LIN UNITS BIT 0=1 = LOG (DB) UNITS BIT 1=0 = ENGINEERING UNITS BIT 1=1 = VOLTS BIT 2=0 = RELATIVE BIT 2=1 = ABSOLUTE BIT 3=0 = NORMALIZED TO BETA BIT 3=1 = NORMALIZED PER HZ

FIGURE 19-10 (Con't.)

CONTENTS OF DATA BUFFER 0

OFFSET FROM FIRST BYTE	NAME	LENGTH (BYTES)	DESCRIPTION
0021	STD TYP	1	DATA TYPE CONTROL 00 = CONTINUOUS 01 = TRANSIENT 02 = ZERO CORRELATION 03 THRU FF INVALID
0022	STFRRD	1	FREQUENCY READS BIT 0=0 = ABSOLUTE FREQUENCY BIT 0=1 = RELATIVE FREQUENCY BIT (1,7)=0 = TRANSLATOR OFF BIT (1,7)=1 = TRANSLATOR ON BITS 2-4 NOT USED BIT 5=0 NO COH BLANKING DURING AVERAGING =1 COH BLANKING DURING AVERAGING BIT 6=0 NO COH BLANKING =1 COH BLANKING
0023	STDSPD	1	DISPLAY DB RANGE 00 INVALID 01 THRU 08 = NUMBER OF DB/20 09 THRU FF INVALID
0024	STPLTR	1	PLOT RATE 00 THRU 05 = SLOW THRU FAST 06 THRU FF INVALID
0025	STINDA	1	INTEGRATE/DIFFERENTIATE FLAG CHANNEL A FE = DOUBLE DIFF (-2) FF = SINGLE DIFF (-1) 00 = NONE (0) 01 = SINGLE INT (+1) 02 = DOUBLE INT (+2) 03 THRU FD INVALID

FIGURE 19-10 (Con't.)

CONTENTS OF DATA BUFFER 0

OFFSET FROM FIRST BYTE	NAME	LENGTH (BYTES)	DESCRIPTION
0026	STINDB	1	INT/DIFF FLAG CHANNEL B SAME AS CHANNEL A
0027	STAVGN	2	AVERAGER N SETTING 1 THRU 9999
0029	STAVGX	2	AVERAGER N SETTING FOR EXP MODE 1 THRU 4096 IN POWERS OF 2
0031	STEXPN	1	LOG BASE 2 OF STAVGX 00 THRU 0C VALID
0032	STDLT A	2	DELAY FROM TRIGGER TO END OF A WINDOW IN SAMPLES
0034	STDLAB	2	DELAY FROM A TO B WINDOWS IN SAMPLES
0036	STDCRN	2	NOT USED
0038		1	DECIMATION RATIO NUMBER FOR DRT
0039	STRXR	5	FREQUENCY RATIO OF BASEBAND 40 BIT INTEGER
0044	STFRRF	5	FREQUENCY REFERENCE 40 BIT INTEGER
0049	STORDR	5	ORDER REFERENCE IN HZ 40 BIT INTEGER

FIGURE 19-10 (Con't.)

CONTENTS OF DATA BUFFER 0

OFFSET FROM FIRST BYTE	NAME	LENGTH (BYTES)	DESCRIPTION
0054	STCOHB	3	COHERENCE BLANKING LEVEL FLOATING POINT
0057	STREFA	3	EU PER VOLTS REFERENCE FOR CHANNEL A FLOATING POINT
0060	STREFB	3	EU PER VOLTS REFERENCE FOR CHANNEL B FLOATING POINT
0063	STREFR	3	REFERENCE LEVEL FOR RELATIVE READINGS FLOATING POINT
0066	STULGM	3	TOP (MAX) FOR UPPER DISPLAY IN LOG FLOATING POINT
0069	STULNM	3	TOP (MAX) FOR UPPER DISPLAY IN LIN FLOATING POINT
0072	STLLGM	3	TOP (MAX) FOR LOWER DISPLAY IN LOG FLOATING POINT
0075	STLLNM	3	TOP (MAX) FOR LOWER DISPLAY IN LIN FLOATING POINT
0079	STBLKS	2	MAXIMUM I/O BLOCK SIZE 2048 MAX
0080	STOUTA	1	AUX OUTPUT TYPE (DEFINE AUX 0-9) 00 = "AT CURSOR" FOR ANALOG PLOTTER 01 = TO DIGITAL PLOTTER OVER RS232 02 = TO DIGITAL PLOTTER OVER 488

FIGURE 19-10 (Con't.)

CONTENTS OF DATA BUFFER 0

OFFSET FROM FIRST BYTE	NAME	LENGTH (BYTES)	DESCRIPTION
0080 (Con't.)			03 = CURSOR FIELDS OUTPUT OVER RS232 04 = CURSOR FIELDS OUTPUT OVER 488 05 THRU 09 SPARE 0A THRU FF INVALID
0081	STREDN	1	REDUNDANCY FLAG (DEFINE AUX 10-13) BIT 0=0 = 50 PERCENT REDUNDANCY BIT 0=1 = 0 PERCENT REDUNDANCY BIT 1=0 = NORMAL TRIGGERING BIT 1=1 = BLOCK SYNC TRIGGERING
0082	STANOT	1	ANNOTATION/GRATICULE CONTROL (DEFINE AUX 20-27) BIT 0=0 = GRATICULE ON BIT 0=1 = GRATICULE OFF BIT 1=0 = ANNOTATION ON BIT 1=1 = ANNOTATION OFF BIT 2=0 = DATA ON BIT 2=1 = DATA OFF BITS 3-7 NOT USED
0083	STOUTF	1	DATA I/O FORMAT (DEFINE AUX 30-37) 00 = ASCII DECIMAL, NO BLOCK FILL 01 = ASCII DECIMAL, WITH BLOCK FILL 02 = ASCII HEX, NO BLOCK FILL 03 = ASCII HEX, WITH BLOCK FILL

FIGURE 19-10 (Con't.)

CONTENTS OF DATA BUFFER 0

OFFSET FROM FIRST BYTE	NAME	LENGTH (BYTES)	DESCRIPTION
0083 (Con't.)			04 = BINARY, NO BLOCK FILL 05 = BINARY, WITH BLOCK FILL 06 = S0/S1 FORMAT - OUTPUT ONLY 07 = S0/S1/S9 FORMAT - OUT- PUT ONLY 08, 09 SPARE 0A THRU FF INVALID
0084	STNOISE	1	SINE WAVE AT CURSOR CONTROL 40 = OFF 41 = SINE WAVE 42 = PSEUDO RANDOM NOISE 43 = PERIODIC NOISE 44 THRU 4F INVALID
0085	STOTRM	1	ASCII OUTPUT TERMINATOR CHAR- ACTERS (DEFINE AUX 50-55) FIRST BLOCK LAST BLOCK 00 = NONE NONE 01 = NONE ETX 02 = CR CR 03 = CR CR, ETX 04 = CR, LF CR, LF 05 = CR, LF CR, LF, ETX
0086	STOHS	1	OUTPUT HANDSHAKE ON/OFF FOR RS232 INTERFACE (DEFINE AUX 60-61) 00 = OFF 01 = ON
0087	STDIA	1	DIAGNOSTIC FLAG BITS (DEFINE AUX 70-79) BIT 0=1 = FFT BYPASS BIT 1=1 = ECHO OFF BIT 2=1 = NO FFT FUNCTIONS PERFORMED

FIGURE 19-10 (Con't.)

CONTENTS OF DATA BUFFER 0

OFFSET FROM FIRST BYTE	NAME	LENGTH (BYTES)	DESCRIPTION
0088	STPAGE	1	ZETA 136A PLOTTER AUTO-PAGING FUNCTION 0 = NO PAGES EJECTED 1 = 1 PAGE EJECTED 2 = 2 PAGES EJECTED 3 = 3 PAGES EJECTED : 9 = 9 PAGES EJECTED
0089	STTEXT	1	TEXT FIELD VIEWING SELECTION 0 = NO TEXT FIELDS DISPLAYED 1 = FIELD #1 DISPLAYED 2 = FIELD #2 DISPLAYED 3 = FIELD #3 DISPLAYED 4 = FIELD #4 DISPLAYED 5 = FIELDS #1-4 DISPLAYED
0090	STNAMP	1	AMPLITUDE OF OUTPUT FROM SINE WAVE AT CURSOR BOARD
0091		21	SPARE

If buffer 0 is output in decimal ASCII format, see "I/O Formats," Section 19.3, each byte is converted to a decimal number between 0 and 255 even if a byte is part of a group of bytes representing one number. For example, if the number of averages has been set to 500, bytes 27 and 28 (STAVGN) would be output as a 1 244 and may be reconstructed by ("1" x 256 + "244") = 500.

Note, although buffer 0 can be used to enter a 660 front panel set-up, no checks are made on the data. The 660 may be placed in an invalid state as a result of an improper input. Buffer 0 should only be used to re-enter a previously saved 660 set-up. To ensure validity, the set-up should be changed only by issuing remote commands or by front panel operations.

After an input of data to buffer 0, the 660 must be told to re-examine its state table to use the new data. This is accomplished by issuing a control A (ASCII SOH) via the controlling interface. This action need be taken only after a transfer to buffer 0.

2. Non-volatile Memory (Buffer 1)

This buffer is used to save front panel settings (Panels 0-9) and cursor locations (Cur Loc 0-9). The ten panels are stored sequentially, followed by the ten cursor locations. Each panel consists of the first 100 bytes of buffer 0, which are copied at the time of the panel save.

Each cursor consists of 2 bytes which form a 16-bit number representing the cell number of the saved cursor. The last 4 bytes of buffer 1 are used for diagnostic purposes.

3. Averager Buffers (Buffers 4, 5, 6, and 7) and Averager Status Buffer (Buffer E)

The averager buffers contain the data needed to generate any averaged function. The data stored in these buffers is dependent upon the mode selected as shown in Figure 19-11.

The data stored in the averager buffers is unscaled data which may be used to calculate any of the available functions for that mode. The formulas for obtaining these functions, as well as the formulas for applying the scale factors contained in buffer 0, can be found in "Calculating and Scaling 660 Data," Section 19.3, Paragraph 7.

The averager status buffer (Figure 19-12) contains information necessary to correctly interpret the averager buffers. This buffer, as well as buffer 0, should be saved whenever the averager buffers are saved.

4. Display Memory Buffers (Buffers 8 and 9) and Display Memory Status Buffer (Buffer A)

The display memory buffers are the areas where data is stored when the display memory STORE button is depressed. The data saved varies with mode, function, and format as indicated in Figure 19-13.

The display memory status buffer contains all the information necessary to correctly interpret the display memory buffers. This status buffer contains a copy of the averager status and front panel settings (buffers E and 0) at the time

FIGURE 19-11

CONTENTS OF AVERAGER BUFFERS

1. Signal Enhancement Mode

Buffer Number(s)	Length (Bytes)	Contents
4, 5	3072	Averaged Channel A time data in floating point (1024 Data Points).
6, 7	3072	Averaged Channel B time data in floating point (1024 Data Points).

2. 2K FFT Mode

4, 5	3075	Averaged Channel A Power Spectrum (1025 Data Points) First Point is Cell 0 or DC.
------	------	---

3. 1K FFT Mode and Corr Mode

4	1539	Averaged Channel A Power Spectrum (513 Data Points) First Point is Cell 0 or DC.
5	1539	Averaged Cross Spectrum Real (513 Data Points).
6	1539	Averaged Cross Spectrum Imaginary (513 Data Points) First Point (DC) and Last Point (Cell 513) is Zero.
7	1539	Averaged Channel B Power Spectrum (513 Data Points).

4. Prob Mode

4	1024	Channel A Probability Density. 256 Data Points of 4 bytes each. First Data Point (4 byte) is total count of points (used for normalization). Remaining 255 Data Points are the number of occurrences in each 'bin'. Data Points are arranged as follows:
---	------	--

NEXT TO LEAST SIGNIFI- CANT BYTE
--

LEAST SIGNIF- CANT BYTE

MOST SIGNIF- CANT BYTE

NEXT TO MOST SIGNIFI- CANT BYTE

LOW ADDR

HI ADDR

FIGURE 19-11 (Con't.)

CONTENTS OF AVERAGER BUFFERS

4. Prob Mode (Con't.)

Buffer Number(s)	Length (Bytes)	Contents
5	1024	Channel B Probability Density. Same format as Prob Mode 4, above.

NOTE: Where two buffer numbers are indicated, the data is stored sequentially, starting with the first buffer indicated.

If the data does not fill a buffer, the extra bytes are meaningless.

FIGURE 19-12

AVERAGER STATUS BUFFER

OFFSET FROM FIRST BYTE	NAME	LENGTH (BYTES)	DESCRIPTION
0000	ASONOF	1	AVERAGER ON/OFF 00 = OFF 01 = ON
0001	ASDSPN	2	VALUE OF N FOR NORMALIZATION OF DISPLAY
0003	ASCNT	2	COUNT OF NUMBER OF AVG FOR SUM SWEEP AND TRANS MODES SET TO 1 FOR EXP AND PEAK MODES (FOR NORMALIZATION)
0005	ASDCNT	2	COUNT OF NUMBER OF AVG FOR DIFF MODE
0007	ASDSPC	2	VALUE OF COUNT FOR DISPLAY IN ALL MODES (USED WHEN THE SEQUENCE RECALL AVG N IS ENTERED)
0009	ASLIMC	2	LIMIT VALUE OF COUNT (ZERO FOR CONTINUOUS MODES)

FIGURE 19-13

CONTENTS OF DISPLAY MEMORY BUFFERS

(Buffers 8 and 9)

MODE	FUNCTION	CHANNEL	FORMAT	CONTENTS
Any but 2K FFT	Input Time	A or B		Contents of A or B input buffer converted to floating point. 1024 Data Points, 3072 Bytes.
Sig Enh	Avg Time	A or B		Copy of contents of Avg buffer. 1024 Data Points, 3072 Bytes.
Sig Enh or 1K FFT or Corr	Inst Spec	A or B		Channel A or B Inst Spectrum Real/Imag in floating point. 511 Data Points each (1533 Bytes each) Real in buffer 8 , Imaginary in buffer 9. NOTE: DC point is not stored. First point is Cell 1.
Sig Enh or 1K FFT or Corr	Inst Spec	A and B	Real or Imag or Mag	Channel A data in buffer 8, Channel B data in buffer 9 in requested format. 511 Floating point. Data Points each (1533 Bytes each). NOTE: DC point is not stored. First point is Cell 1.
Sig Enh or 1K FFT or Corr	Inst Spec	A and B	Phase	Channel A data is in buffer 8, and Channel B data is in buffer 9. There are 511 Data Points in each buffer (1533 Bytes). No DC point is stored. Data is stored as 3 bytes. The first byte contains no information. The remaining two bytes form a 16-bit number representing the phase as a fraction of one rotation. Binary point is after the sign bit.
2K FFT	Inst Spec	A	Real or Imag or	Data in requested format stored in floating point. 1023 Data Points, 3069 Bytes. NOTE: DC Point is not stored. First point is Cell 1.

FIGURE 19-13 (Con't.)

CONTENTS OF DISPLAY MEMORY BUFFERS

(Buffers 8 and 9)

MODE	FUNCTION	CHANNEL	FORMAT	CONTENTS
2K FFT	Inst Spec	A	Phase	Phase data stored. 1023 Data Points, 3069 Bytes. No DC point stored. First Data point is Cell 1. Data format same as phase on other modes, see previous.
2K FFT	RMS Spec or Power Spec	A		Copy of averager buffers 4 and 5. (Power Spectrum) 1025 Data Points, 3075 Bytes.
1K FFT or Corr	RMS Spec or Power			Copy of averager buffers 4 and 7. That is, power spectrum A and power spectrum B. 1513 Data Points, 1539 Bytes each.
1K FFT or Corr	COP			Coherent Output Power in floating point. 513 Data Points, 1539 Bytes. Buffer 9 not used.
1K FFT	COH			Coherence Data in floating point. 513 Data Points, 1539 Bytes. Buffer 9 not used.
1K FFT or Corr	Cross Spec			Cross Spectrum Real and Imaginary. Real stored in buffer 8. Imaginary stored in buffer 9. 513 Floating point data points each, 1539 Bytes each.
1K FFT or Corr	TM			Transmissibility Function. 513 Floating point data points, 1539 Bytes. Buffer 9 not used.
1K FFT or Corr	Auto Corr			Same as RMS Spec or Power Spec.
1K FFT or Corr	Cross Corr			Cross correlation function in floating point. 1024 Data Points, 3072 Bytes.
1K FFT or Corr	Impulse Response			Impulse response function in floating point. 1024 Data Points, 3072 Bytes.

FIGURE 19-13 (Con't.)

CONTENTS OF DISPLAY MEMORY BUFFERS

(Buffers 8 and 9)

MODE	FUNCTION	CHANNEL	FORMAT	CONTENTS
1K FFT	TF			Transfer Function Real and Imaginary. Real stored in buffer 8 and imaginary stored in buffer 9. 513 Floating Point Data points each, 1539 Bytes each.
PROB	Prob Den or Cum Dist			Copy of averager buffers 4 and 5. 1024 Bytes each.

the display memory store pushbutton was depressed, see Figure 19-14. Only buffer A need be saved with buffers 8 and 9.

5. Text Buffer (Buffer B)

The text buffer is used to save or restore the four optional text fields described in the Options Section. The buffer contains the four-45 character fields and 32 bytes of position control status. The buffer does not control which text is on the display. This is specified by the 90 DEF AUX series. Figure 19-14A details the contents of the text buffer.

6. General Block (Buffer F)

Buffer F does not correspond to any internal data buffer in the 660, but rather enables the user to access any portion of the 660 memory. When using buffer F, the blocksize is interpreted not as a blocksize, but as the number of internal bytes to be transferred. This byte count may differ from the number of characters that are output or input, depending on the format selected. For example, if the blocksize has been set to 20 and hexadecimal format is selected, 40 characters will be output since for each byte, two hexadecimal digits are output.

The starting location for the I/O is determined by an address placed in the entry field. This address is assumed to be in hexadecimal unless the digits are followed by a decimal point, in which case the address is assumed to be decimal. For example, to output the 25 bytes starting at location 40A0₁₆

FIGURE 19-14

CONTENTS OF DISPLAY MEMORY STATUS BUFFER (Buffer A)

OFFSET FROM FIRST BYTE	LENGTH (BYTES)	DESCRIPTION
0	1	DM TYPE 00 = No data 01 = 1 Function Stored 02 = 2 Functions Stored
1	2	DM = CURSOR LOCATION AT TIME OF DISPLAY MEM- ORY STORAGE
3	11	COPY OF AVERAGER STATUS BUFFER (Buffer E)
14	1	RS 232 BAUD RATE 00 = 110 BAUD 2 STOPBITS 01 = 150 BAUD 1 STOPBIT 02 = 300 BAUD 1 STOPBIT 03 = 600 BAUD 1 STOPBIT 04 = 1200 BAUD 1 STOPBIT 05 = 2400 BAUD 1 STOPBIT 06 = 4800 BAUD 1 STOPBIT 07 = 9600 BAUD 1 STOPBIT
15	1	SPARE
16	1	RS232 PARITY 00 EVEN 01 ODD 02 NONE 03 NONE
17	1	488 ADDRESS
18	1	00 THRU IE VALID IF THRU FF INVALID SPARE
19	1	488 CONTROLLER PRESENT 00 = NO CONTROLLER 01 = CONTROLLER
20	111	COPY OF FRONT PANEL SETTINGS (BUFFER 0)

FIGURE 19-14A

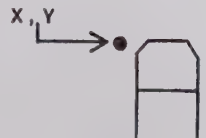
CONTENTS OF TEXT BUFFER (BUFFER B)

OFFSET FROM FIRST BYTE	LENGTH (BYTES)	DESCRIPTION
0	45 *00	CHAR TEXT STRING #1, (END OF STRING NULL)
46	45 *00	CHAR TEXT STRING #2, (END OF STRING NULL)
92	45 *00	CHAR TEXT STRING #3, (END OF STRING NULL)
138	45 *00	CHAR TEXT STRING #4, (END OF STRING NULL)
		FIELD #1 POSITION CONTROL
186	*0200 XXXX	NOTE 1 16-BIT UNSIGNED X POSITION OF 1ST CHARACTER
188	YYYY	16-BIT UNSIGNED Y POSITION OF 1ST CHARACTER
	*07	NOTE 1
	*----	NOTE 1
195 197	[X Y	DITTO FOR FIELD #2
204 206	[X Y	DITTO FOR FIELD #3
213 215	[X Y	DITTO FOR FIELD #4

*For proper operation, user should not alter these values.

NOTE 1: Internal Control Bytes.

NOTE 2: X and Y reference upper left of 1st character. Character size is 400 x 400 Hexidecimal. The 0,0 coordinates are the extreme lower left of the CRT screen. Power up coordinates are X = 0 and Y = A800.



over an interface, the following commands would begin the output:

25SWA	Set Blocksize to 25
Control ^	Enter Entry Field Alpha Mode
40A0	Scroll Address into Entry Field
Control \	Enter Entry Field Alpha Mode
?F	Output Buffer F over the IEEE-488 Interface

Since the number of bytes transferred is controlled by the block-size, this number must be between 1 and 2048, inclusive.

7. Calculating and Scaling Data

This section describes how data and scaling factors sent over the interface can be combined to determine equivalent input (BNC terminal) scaled values. However, before presenting the equations, an overview of the data organization will clarify how to use the equations.

a. Data Overview - Data is supplied from six buffers, buffers 4, 5, 6, and 7 called the averager buffers and buffers 8 and 9 called the display memory buffers. The associated scaling information for these two groups is located in buffers E and 0 for the averaged data and buffer A for the display memory buffers.

Three general types of data are used within the 660 Spectrum Analyzer - instantaneous, averaged and derived (calculated) data.

1. Instantaneous Data - These data include instantaneous time and spectrum data. These data are not normally found in the above six buffers and cannot be accessed

over the interface unless transferred to the display memory buffer. Therefore, buffers 8 & 9 are used to obtain instantaneous spectrum data. The data format consists of 24-bit floating point numbers. The instantaneous spectrum data consist of the real and imaginary components of the spectrum.

2. Averaged Data - Data found in the averager buffers is either time, probability density, or four spectrum quantities: Power Spectrum A, Power Spectrum B, the Colinear (CO) component of the Cross Spectrum, and the Quadrature (QUAD) component of the Cross Spectrum.

3. Derived (Calculated) Data - Most of the functions displayed on the 660 CRT are functions derived from averaged data. Included among these functions are:

- a. Coherence (COH)
- b. Transfer Function (TF)
- c. Transmissibility (TM)
- d. Coherent Output Power (COP)
- e. Cross Correlation (CC)
- f. Auto Correlation (AC)
- g. Impulse Response (IR)
- h. RMS Spectrum
- i. Cumulative Distribution

For example, the coherence function is derived using the power spectrum data from Channels A and B and the CO and QUAD components of the cross spectrum. In fact, functions a thru h make use of one or more of the four averaged spectrum data. Function i is derived from the averaged probability density function. These derived data are not available to the interface unless transferred to the display buffer memory first.

If the data is not transferred, the user will have to take the averaged buffer data and perform the calculations outside the instrument.

b. Derived Data Equations - This section will describe how the derived functions are calculated within the analyzer from the "raw" averaged data.

T_A	= Averaged Time Channel A	= Buffer 4 and 5
T_B	= Averaged Time Channel B	= Buffer 6 and 7
P_A	= Power Spectrum Channel A	= Buffer 4
CO	= Colinear Component of Cross Spectrum	= Buffer 5
$QUAD$	= Quadrature Component of Cross Spectrum	= Buffer 6
P_B	= Power Spectrum Channel B	= Buffer 7
N	= 1 for Peak and Exponential	= N number of averages for summation.
F^{-1}	= Inverse Fourier Transform	
*	= Can be transferred to Display Memory	

$$\text{*Power Spectrum Channel A} = \frac{P_A}{N}$$

$$\text{*Power Spectrum Channel B} = \frac{P_B}{N}$$

$$\text{RMS Spectrum Channel A} = \left(\frac{P_A}{N} \right)^{1/2}$$

$$\text{RMS Spectrum Channel B} = \left(\frac{P_B}{N} \right)^{1/2}$$

Cross Spectrum

$$*a. \text{ Real} = \frac{CO}{N}$$

$$*b. \text{ Imaginary} = \frac{QUAD}{N}$$

$$c. \text{ Magnitude} = \frac{(CO^2 + QUAD^2)^{1/2}}{N}$$

$$d. \text{ Phase} = \text{Tan}^{-1} \left(\frac{QUAD}{CO} \right)$$

Averaged Transfer Function (TF)

$$*a. \text{ Real} = \frac{CO}{P_A}$$

$$*b. \text{ Imaginary} = \frac{QUAD}{P_B}$$

$$c. \text{ Magnitude} = \frac{(CO^2 + QUAD^2)^{1/2}}{P_A}$$

$$d. \text{ Phase} = \text{TAN}^{-1} \left(\frac{QUAD}{CO} \right)$$

$$*Average \text{ Transmissibility (TM)} = \left(\frac{P_B}{P_A} \right)^{1/2}$$

$$*Average \text{ Coherence (COH)} = \frac{CO^2 + QUAD^2}{P_A \cdot P_B}$$

$$*Average \text{ Time Channel A} = \frac{T_A}{N}$$

$$\text{Average Time Channel B} = \frac{T_B}{N}$$

*Can be transferred to Display Memory.

$$\text{*Average Coherent Output Power (COP) = } \frac{\text{CO}^2 + \text{QUAD}^2}{\text{N} \cdot \text{P}_A}$$

$$\text{Auto Correlation (AC) = } F^{-1} \left(\frac{\text{P}_A}{\text{N}} \right)$$

$$\text{Cross Correlation (CC) = } F^{-1} \left(\frac{\text{CO} + j\text{QUAD}}{\text{N}} \right)$$

$$\text{*Impulse Response = } F^{-1} \left(\frac{\text{CO} + j\text{QUAD}}{\text{P}_A} \right)$$

c. Scaling Formulas - To determine the scaled input value requires modifying the data according to the following equations. The abbreviation D will be used for the data portion of the equation. The definition of D is given in the cross reference table accompanying the equations.

In the equations presented in this section, N, the correction for the number of averages, is included. It should be made clear that the N in the following equations is the same used previously and correction by N should only be done once. For example in Equation 4 below, D is equal to P_A or P_B not $\frac{\text{P}_A}{\text{N}}$ or $\frac{\text{P}_B}{\text{N}}$.

S = Scaled Value

D = Data

ATT_A = A/D Converter Full Scale, Channel A

ATT_B = A/D Converter Full Scale, Channel B

ATT_C = A/D Converter Full Scale, Current Channel (A or B)

EU/V_A = Engineering Units/Volt, Channel A
 EU/V_B = Engineering Units/Volt, Channel B
 EU/V_C = Engineering Units/Volt, Current Channel (A or B)
 R = Relative Factor
 N = Number of Averages Completed
 1 for EXP or PEAK Averaging
 β = Noise Bandwidth of Analysis Range if Normalized
 Per Hertz Otherwise, 1.0
 Noise Bandwidth = 1.0 * Cell Width if Flat Weighting
 1.944 * Cell Width if Hanning Squared
 Weighting
 ω = Frequency of Data Point in Radians/Sec
 W = Weighting Factor: 2.0 - Flat Weighting
 1.333 - Hanning Squared Weighting
 4.0 - Correlation Mode Window
 EQ = Equalization Factor (Transfer Functions Only)

$$\frac{\text{Transfer Function (Current)}}{\text{Transfer Function (Stored)}}$$

 n_C = Number of Differentiations Performed on the Current
 Channel
 . 0 = No Differentiation
 Negative = Indicates Integration
 n_A = Same for Channel A
 n_B = Same for Channel B
 T₂ = DRT Factor: 1 = No Translation
 2 = In Translation
 T₄ = DRT Factor: 1 = No Translation
 4 = In Translation

NOTE: THE RELATIVE FACTOR AND THE ENGINEERING
 UNITS/VOLT ARE MUTUALLY EXCLUSIVE.

FORMULAS:

1. INPUT TIME DATA: $S = D * ATT_C * EU/V_C * R$

2. AVERAGED TIME DATA: $S = D * ATT_C * EU/V_C * R * \frac{1}{N}$

3. RMS SPECTRUM:

$$S = \sqrt{D} * \frac{ATT_C}{\sqrt{2}} * EU/V_C * R * W * [(j\omega)^{n_C}] * \frac{1}{\sqrt{\beta}} * \frac{1}{\sqrt{N}} * T_2$$

4. POWER SPECTRUM:

$$S = D \left(\frac{ATT_C}{2} \right)^2 (EU/V_C)^2 * R * W^2 * [(j\omega)^{2n_C}] * \frac{1}{\beta} * \frac{1}{N} * T_4$$

5. INSTANTANEOUS SPECTRUM:

$$S = D \frac{ATT_C}{\sqrt{2}} * EU/V_C * W * R * [(j\omega)^n] * \frac{1}{\sqrt{\beta}} * T_2$$

6. CROSS SPECTRUM:

$$S = D * \frac{ATT_A}{\sqrt{2}} * \frac{ATT_B}{\sqrt{2}} * EU/V_A * EU/V_B * W^2 * R * \frac{1}{\beta} * |(j\omega)^{n_A+n_B}| * \frac{1}{N} * T_4$$

7. TRANSFER FUNCTION:

$$S = D * \frac{ATT_B}{ATT_A} * \frac{EU/V_B}{EU/V_A} * |(j\omega)^{n_B-n_A}| * R * EQ$$

FORMULAS (Con't.):

8. COHERENCE: $S = D$

9. COHERENT OUTPUT POWER:

$$S = D * \frac{ATT_B}{\sqrt{2}}^2 * (EU/V_B)^2 * W^2 * \frac{1}{\beta} * |(j\omega)^{2n_B}| * R * \frac{1}{N} * T_4$$

10. TRANSMISSIBILITY:

$$S = D * \frac{ATT_B}{ATT_A} * \frac{EU/V_B}{EU/V_A} * |(j\omega)^{n_B - n_A}| * EQ$$

11. PROBABILITY DENSITY:

$$S = \frac{64}{ATT_C} * \frac{1}{EU/V_C} * R * D$$

12. IMPULSE RESPONSE:

$$S = D * \frac{ATT_B}{ATT_A} * \frac{EU/V_B}{EU/V_A} * |(j\omega)^{n_B - n_A}| * EQ * T_4$$

13. CROSS CORRELATION:

$$S = D * ATT_A * ATT_B * EU/V_A * EU/V_B * W^2 * R * \frac{1}{N} * |(j\omega)^{n_A + n_B}| * T_4$$

14. AUTO CORRELATION:

$$S = D * ATT_C * EU/V_C * (W)^2 * \frac{1}{N} * |(j\omega)^{2n_C}| * R * T_4$$

BUFFER NUMBER											
FUNCTION	0 ¹	1	4	5	6	7	8	9	A ³	B	E ¹
INPUT TIME	FRONT PANEL SETTING	NONVOLATILE	2	2	2	2		TIME ⁶	DISPLAY MEMORY STATUS	TEXT STRING	AVERAGE STATUS
AVERAGE TIME			A TIME	A TIME	B TIME ⁴	B TIME ⁴	TIME ⁶	TIME ⁶			
INST SPECTRUM			2	2	2	2	SEE EXCERPT				
RMS SPECTRUM			P _A	CO ⁴	QUAD	P _B	P _A	P _B			
POWER SPECTRUM			P _A	CO ⁴	QUAD	P _B	P _A	P _B			
CROSS SPECTRUM			P _A	CO	QUAD	P _B	CO	QUAD			
TF			P _A	CO	QUAD	P _B	TF _R	TF _I			
TM			P _A	CO	QUAD	P _B	TM	2			
COH			P _A	CO	QUAD	P _B	COH	2			
COP			P _A	CO	QUAD	P _B	COP	2			
IMPULSE RESPONSE			P _A	CO	QUAD	P _B	IMP RESP	2			
CROSS CORR.			P _A	CO	QUAD	P _B	CO	QUAD			
AUTO CORR.			P _A	CO	QUAD	P _B	P _A	P _B			
PROB. DENSITY			A PROB. DENSITY	B PROB. DENSITY	2	2	A PROB. DENSITY	B PROB. DENSITY			

¹These buffers are always needed to correctly interpret the Averager buffers (4, 5, 6, 7).

³This buffer is always needed to correctly interpret the Display Memory buffer (8, 9).

⁵The phase is equal to:
[(decimal value) - 16384] * 0.01098632813

²This buffer has no data pertaining to this function.

⁴In the 2K mode, this buffer contains the second half of the channel A data.

⁶These buffers have the Time data for either channel A or B.

TABLE 14-B. CROSS REFERENCE, CONTENTS OF 660 BUFFERS

EXCERPT

(INSTANTANEOUS SPECTRUM ONLY)

FUNCTION	BUFFER NUMBER	
	8	9
CHANNEL A & B REAL	A REAL	B REAL ⁴
CHANNEL A & B IMAG	A IMAG	B IMAG ⁴
CHANNEL A & B MAG	$\sqrt{A_R^2 + A_I^2}$	$\sqrt{B_R^2 + B_I^2}$ ⁴
CHANNEL A & B PHASE	A PHASE ⁵	B PHASE ^{4, 5}
CHANNEL A OR B	REAL	IMAG

¹These buffers are always needed to correctly interpret the Averager buffers (4, 5, 6, 7).

²This buffer has no data pertaining to this function.

³This buffer is always needed to correctly interpret the Display Memory buffer (8, 9).

⁴In the 2K mode, this buffer contains the second half of the channel A data.

⁵The phase is equal to:
[(decimal value) - 16384] * 0.01098632813

⁶These buffers have the Time data for either channel A or B.

TABLE 14-B. EXCERPT FOR CROSS REFERENCE, CONTENTS OF 660 BUFFERS

B. Internal Data Formats

Data in the 660 is stored in various formats. It is assumed that the reader is familiar with Radix 2 to Radix 10 conversion. The features of each format follow:

1. 8-Bit Bytes - This is the simplest format.

Each byte represents an unsigned, positive integer in binary format. Since a byte consists of 8 bits, the range of numbers is 00000000 to 11111111.

2. 16-Bit Integers - This format groups two bytes together to form one 16-bit binary number. The numbers are stored in two's complement form. The most significant bit (MSB) of each number is the sign bit. If the MSB is zero, the number is positive and the remaining 15 bits are interpreted as a binary number in the usual manner. If the MSB is one, the number is negative. To determine the absolute value, the number must be two's complemented. For example, consider the negative number 11 - - - - -110101 . To find the absolute value, complement each bit 00 - - - - -001010 . And add one to the result 00 - - - - -001011 . Since this bit pattern represents the decimal number 11, 11 - - - - -110101 represents -11.

3. 40-Bit Scaled Integers - This format is simply a number, multiplied by 100,000, converting to

INTERNAL NUMBER FORMATS

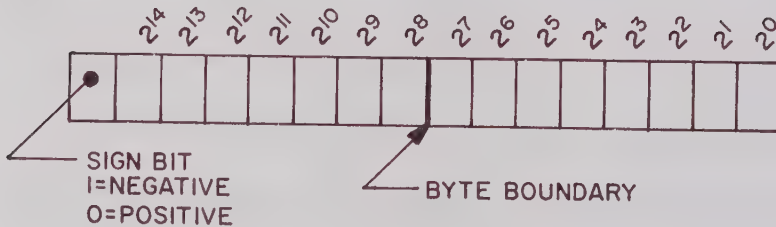
FIGURE 19-15

8-BIT INTEGERS



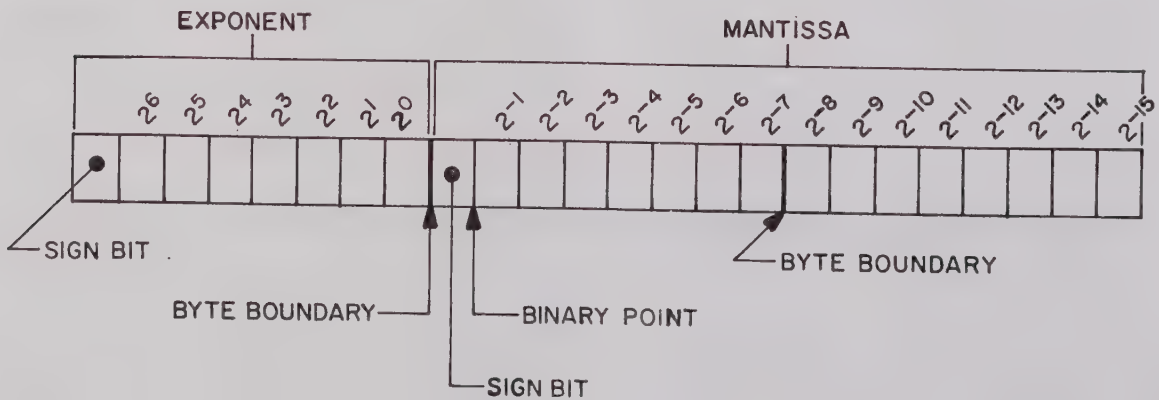
RANGE 0 TO 255 (2^8-1)

16-BIT INTEGERS



RANGE $-32,768 (-2^{15})$ TO $+32,767 (2^{15}-1)$

3 BYTE FLOATING POINT NUMBERS



binary. Resolution is always 1/100,000, full two's complement. To decode, divide by 100,000.

4. 3 Byte Floating Point Numbers - To provide for a large range of numbers and to allow for fractional quantities, a floating point format is used for most of the data in the 660. Numbers in this format consist of 3 bytes; the first byte is the characteristic in two's complement format. The second and third byte form a 16-bit mantissa. The mantissa is in a normalized two's complement format with the binary point after the most significant bit. Hence, the range of positive mantissas is $1/2$ (0100-----00) to $1-1/16,324$ (011-----11) and the range of negative mantissas is -1 (10-----00) to $-(1/2 + 1/16,324)$ (1011-----11). The only mantissa which is not normalized and not in one of these ranges is zero (16 zero bits).

The value represented by a floating point can be found by using the relationship

$$\text{Value} = \text{Mantissa} \times 2^{\text{Characteristic}}$$

In the following example, the bit patterns are represented as hexadecimal digits to avoid the appearance of many ones and zeroes. These examples indicate the conversion process for the four possible kinds of floating point numbers.

a. Positive Mantissa and Positive Characteristic - An example of a floating point number with a positive

mantissa and a positive characteristic is 02 60 00. The MSB of the characteristic (02) is zero, so the value is +2. The MSB of the mantissa is zero, so the mantissa is positive and its value is $2^{-1} + 2^{-2} = .5 + .25 = .75$. Therefore, the number is $.75 \times 2^2 = 3$.

b. Positive Mantissa and Negative Characteristic - A positive mantissa and a negative characteristic will yield a positive number which is always less than one. For example, FE 60 00 has a negative characteristic, since the MSB is one. The absolute value of the characteristic is 2 found by taking the two's complement of FE. Hence, the value of the number is $.75 \times 2^{-2} = 3/4 \times 1/4 = 3/16$.

c. Negative Mantissa and Positive Characteristic - The sign of a floating point number is determined by the sign of the mantissa. A negative mantissa with a positive characteristic is a negative number whose absolute value is greater than or equal to one. Since the MSB of the mantissa 02 A0 00 is one, the mantissa is negative. Taking the two's complement of the mantissa yields 02 60 00. Since this number equals 3 as previously shown, $02\ A0\ 00 = -3$.

d. Negative Mantissa and Negative Characteristic - Negative numbers with absolute values less than one can be represented using a negative mantissa and a negative character-

istic. The value of FE A0 00 can be found by taking the two's complement of both the exponent FE (02) and the mantissa A0 00 (60 00). This number, then is $-.75 \times 2^{-2} = -3/4 \times 1/4 = -3/16$. Other examples of floating point numbers follow:

00 00 00	Zero, the only number with an unnormalized mantissa
80 40 00	The smallest possible positive number, equal to $2^{-1} \times 2^{-128} = .5 \times 2^{-128}$
7F 7F FF	The largest possible positive number, equal to $(2^{-1} + 2^{-2} + 2^{-3} + \dots + 2^{-15}) \times 2^{127}$
7F 80 00	The negative number with the largest absolute value, equal to -1×2^{127}
80 BF FF	The negative number with the smallest absolute value, equal to $-(1/2 + 1/16384) \times 2^{-128}$
01 40 00	Equal to one, $1/2 \times 2^1$

C. I/O Formats

1. Selecting Formats and Blockfill

Three formats are provided to allow flexibility during I/O and external data manipulation. The format is selected using the 30 series of DEFINE AUX. In addition, this DEFINE AUX series determines if blockfill is to be used on output. See section, "DEFINE AUXiliary Selectable Parameters," 19.2, Paragraph A. Blockfill is used in conjunction with the blocksize to determine the number of bytes to output. If the number of

data bytes in a block is less than the blocksize, a number of fill characters equal to the difference between the blocksize and the number of data bytes is output. For example, if the blocksize has been set as 72 and there are 70 data bytes in a particular block, then 70 bytes will be output by the 660 if no blockfill is selected. If blockfill is selected, an additional 2 characters will be output by the 660.

The blockfill filler characters are blanks if the format is ASCII and nulls if the format is binary. Blockfill is optional only on output. On input to the 660, all buffers must be blockfilled. The last block need not be blockfilled if one of the following conditions exist:

- a. Input is taking place over the IEEE-488 interface and the EOI line is used to signal the end of the transfer, or
- b. If the format is ASCII, and EOT (control D) byte may be used to signal the end of the transfer when using either the RS232-C or IEEE-488 interfaces.

Formats and blockfill specified by the 30 series of DEFINE AUX are ignored when using the 16-Bit Parallel interface. The I/O over this interface is always in binary format and the exact number of 8-bit bytes is output 2 at a time. If the number of bytes is odd, the lower 8 bits are meaningless when outputting or inputting the last word.

2. Binary Format

This is the simplest format. Each internal data byte is simply copied to the appropriate interface on output. On input, a byte entered from the interface in use is copied into the appropriate byte in the data buffer. This format provides the fastest I/O time and most compact means of externally storing data. Binary format is selected by entering the sequence 34 SET DEF AUX. Output blockfill, if used, (35 SET DEF AUX) uses nulls as fill characters on the last block.

3. Hexadecimal ASCII

This format is the next level up in complexity from binary format. It is useful in systems where the RS232-C parity cannot be turned off as it must be to successfully transmit 8-bit data in binary format. In hexadecimal ASCII format, each byte is split in half. Each half byte is then converted to a hex digit and the ASCII equivalent for each digit is output over the interface. For example, the byte 1010 0011 would be output as the ASCII characters A 3.

Hexadecimal format is selected by the pushbutton sequence 32 SET DEF AUX. If 33 SET DEF AUX is entered, blanks will be used as blockfill in each buffer.

On input, all characters other than hex digits 0-9 and A-F are ignored, except for an EOT (control D) which may terminate the input. The hex digits may be separated at any point by as many other characters, usually blanks, as the user desires. Splitting the two characters associated with one byte across a block boundary is not allowed and results in an I/O non-recoverable error. The message BYTE SPLIT ACROSS BLOCK is displayed in the entry field. For example, if the blocksize is 13 and the characters 0 1 2 3 4 5 6 7 8 9 A B C 0 1 2 3 4 5 6 7 8 9 A B 0 are input, this error will result because the digit C is the last character of the first 13 byte block and 0 is the first character in the next block.

The internal format of data has no effect on the output when binary or hexadecimal ASCII format is in use. Each internal byte is simply output over the interface. Similarly on input, bytes are received from the interface, converted from hexadecimal ASCII if necessary, and stored in the next appropriate location. If one of these formats is used, the user must be cognizant of the internal format in order to interpret the data and manipulate it properly.

4. Decimal ASCII

If the sequence 30 SET DEF AUX is entered, decimal ASCII format is selected. Unlike binary and hexadecimal

ASCII format, the characters output by the 660 depend on the internal format. If the internal format is 8-bit bytes, each byte is converted to a decimal number 0 to 255 and these digits are output in ASCII in a 4 character field padded on the left with as many blanks as required. For example, the decimal number 27 would be output as `27` where =blank.

If the data buffer contains 16-bit integers, each datum, 2 bytes, is converted to a decimal -32768 to 32767 and these digits are output in ASCII in an 8 character field padded on the left with blanks. For example, the decimal number 1025 would be output as `1025`.

Numbers represented internally as 3 byte floating point numbers are output in an ASCII exponential format in a 12 character blank filled field. The general format of this field is leading blanks, minus sign if the number is negative, 4 digits of mantissa with floating decimal point, and characteristic with sign. The decimal point is shifted prior to output so that the characteristic is always a multiple of three. A typical output of `12.73+03` is 12.73×10^3 .

On input, a general format can be used to enter decimal ASCII numbers. All characters except for digits, signs, and decimal points are ignored and can be used as number separators. If integers are being entered, decimal points are considered number separators.

If too small or too large a number is entered, it is replaced by zero or the largest possible number of the correct sign, respectively. In addition, the message NUMBER RANGE is displayed in the cursor horizontal field. When the data buffer contains 8-bit integers, however, no error message is displayed and modulo 256 of the input is stored.

If a floating point data buffer is being input, exponential or fixed point formats may be used to enter the data. If exponential format is used, the following rules must be observed:

1. No separator characters may appear between the mantissa and the characteristic, and
2. The characteristic must be 2 digits.

Except for the rules mentioned above, decimal data may be entered in free format. For example, the sequences 1023 or +1.023+03 or 1023000-03 all input the number 1023. As with hexadecimal numbers, numbers may not be split across a block boundary. If split, the 660 will view the two halves of the number as two distinct numbers.

5. Output Terminators

When outputting ASCII data either hexadecimal or decimal over the RS232-C or IEEE-488 interfaces, the 660 may be requested to output terminating characters after each block.

These characters are specified by the 50 series of DEFINE AUX in Figure 19-3 and are not included in the blocksize. For example, if the blocksize is 72 bytes and 55 DEF AUX is specified, each block will contain 74 characters of which 72 are data bytes and one each for carriage return and line feed. The last block will contain 75 characters of which 72 are data bytes and one each for carriage return, line feed, and EOT.

On input, the setting of the 50 series of DEFINE is ignored. No terminating characters are allowed except ETX (CNTRL/D) which will terminate input even in the middle of a block.

NOTE: Output terminators can not be used in binary format.

D. Starting and Cancelling I/O

The following steps provide a check list and a summary of the procedures required to transfer data to and from the 660.

1. Set hexadecimal switches on Executive Board for interface configuration desired. Press SYS RST.
2. Select parameters for data transfer.
 - a. Set blocksize (1 to 2048 allowed).
 - b. Select desired I/O format with or without buffer fill on outputs.
 - c. Select buffer terminators for output only.
 - d. If data is output over RS232-C interface, determine if software handshake is necessary.
3. If the 660 is to output data, perform steps to have the 660 calculate data. If inputting data to the 660, prepare data for transfer across the interface.
4. Initiate data transfer using one of the external I/O initiate commands.

5. At the conclusion of a successful data transfer, an ACK is issued over the interface, (see Section 19.2, Paragraph C, "Acknowledging Commands"). If a recoverable error occurred, a NAK is issued over the interface. Also, an error message is displayed in the cursor horizontal field. If a non-recoverable error occurred at any time, the I/O is terminated, and a rotating error message appears in the entry field. In addition, if the RS232-C is the active interface, a NAK is output. If the IEEE-488 is the active interface, a service request is issued and the non-recoverable I/O error bit pattern is set in the serial poll status byte. If this occurs, the 660 I/O section must be reset by pressing CRT ONLY pushbutton. A 488 bus controller can reset the I/O section by issuing the GO TO LOCAL command.
6. The user may cancel the I/O at any time by pressing the CRT ONLY pushbutton. If the front panel is locked out as it is with transfers of most data buffers, the CRT ONLY command can be sent over an interface, provided the data transfer is not taking place over the same interface.

E. Supplemental Data

The majority of the information which the 660 can provide is available from the data buffers by using the external I/O initiate commands. Two buttons, DISK and AUX, on the 660 provide for outputting additional data which may be useful in certain applications.

When the DISK pushbutton is used and the sequence SET DISK or RECALL DISK or CLEAR DISK is entered, the contents of the entry field preceded by an S, R, or Z are output over the IEEE-488 interface. Since the entry field is 14 characters long, 15 ASCII characters are output. This output is useful for determining if the 660 has responded properly to a

remotely issued command sequence. Note, the following limitations apply:

1. Since the CLEAR pushbutton may blank out the entry field, the probable output using the sequence CLEAR/DISK is a Z followed by 14 blanks.
2. The 660 will output a lower case d as a dollar sign \$.

The second source of supplemental data is the AUX pushbutton. The data output by this pushbutton is determined by the zero series of DEFINE AUX, see "DEFINE AUX Selectable Parameters," Section 19.2, Paragraph A. The default output of the AUX pushbutton is the ASCII character string necessary to generate a plot on the 134A and 136A Digital Plotters. This output occurs over the RS232-C interface.

AUX 2 provides for plot output over the 488. The output is the same as AUX 1 (the default) would send over RS232-C, but the last byte is sent with an EOI. All outputs over 488 end with an EOI on the last byte.

If the sequence 0 SET DEF AUX is entered, pressing the AUX pushbutton will cause the analog X-Y Plotter connectors J118, J119, and J120 to output the voltages corresponding to the point on the display indicated by the cursor. This REST AT CURSOR mode can be used, for example, to record the time history of the amplitude at a particular frequency on a strip chart recorder.

AUX 3 and 4 provide for outputting the cursor fields over the RS232-C and the IEEE-488 (1975) interfaces, respectively. In these modes the data which is output over the appropriate interface is the entry field, the cursor horizontal field, the upper cursor amplitude field, and the lower cursor amplitude field, in that order. The data is output in ASCII format; the same characters which are displayed on the CRT are output over the interface except for the lower case d which is output as a dollar sign \$. The length of the fields is 14 bytes each. If a field is blank, a number of blanks equal to the length of that field are output. In addition, each field is terminated with the characters specified by the current setting of the 50 DEFINE AUX series.

As with any I/O, any AUX pushbutton output may be cancelled by depressing the CRT ONLY pushbutton in the OUTPUT TYPE section of the 660.

Additional supplemental data may be obtained from the 660 status byte. The format of this byte and the commands to cause its output are discussed in the "Additional Remote Commands," Section 19.2, Paragraph C.

19.4 Connecting to the Interfaces

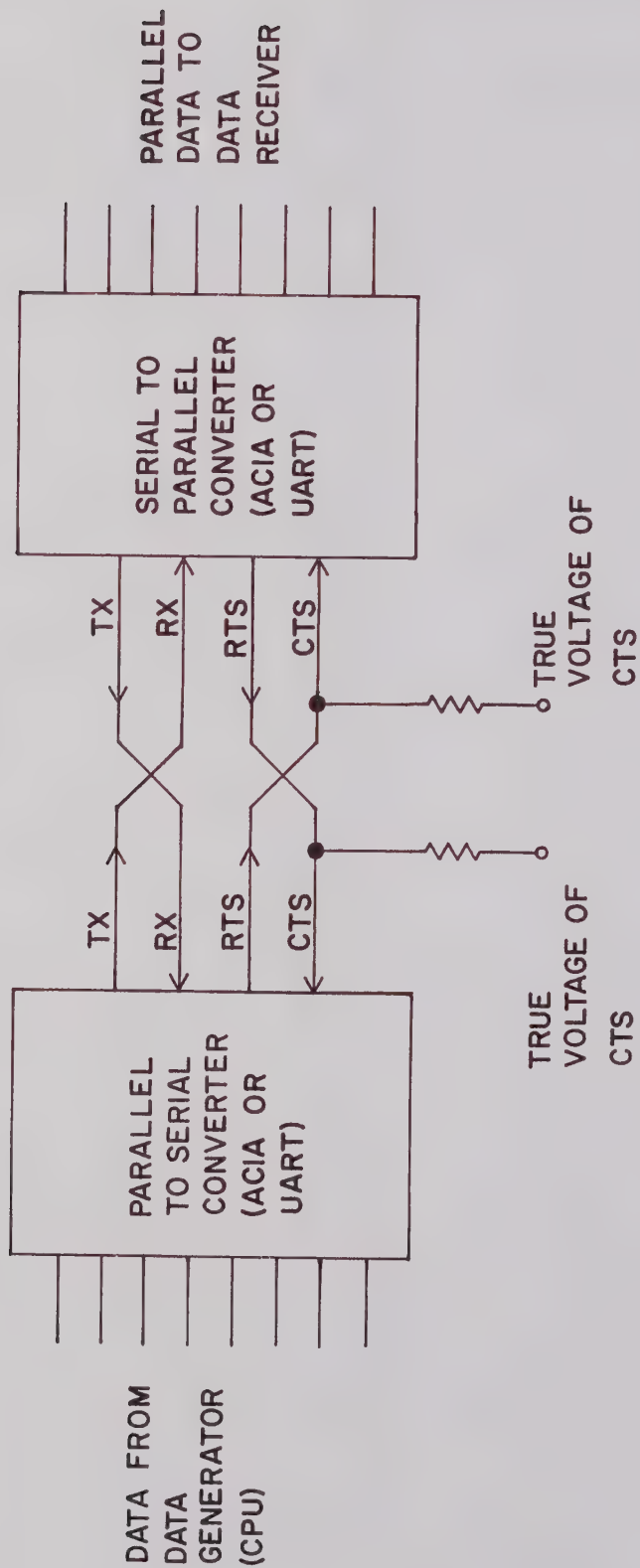
In this section, the details of connecting to each interface are discussed. A list of signal names and pin assignments for each interface is contained in the Appendix, Section 19-5, and should be referenced in conjunction with this section when fabricating the interface cables.

A. RS232-C

Perhaps the simplest interface to implement from a hardware viewpoint is the RS232-C interface. Figure 19-16 illustrates a typical interconnection between two devices. The data transfer takes place over two wires. Each device has a data out port (TX) and a data in port (RX) and the TX port of one device is connected to the RX port of the other.

Data from the sender is presented, usually in 8-bit bytes, to the parallel-to-serial converter. The converter sends the byte out the TX port, one bit at a time, LSB first as shown in Figure 19-17. When no data is being transmitted, the logic true level is sent. A start bit, a logic false level of one bit width in duration, precedes each character. The character is terminated by one or two stop bits, a logic true level of one bit width in duration. Two stop bits are used at 110 baud and one stop bit is used at all other baud rates.

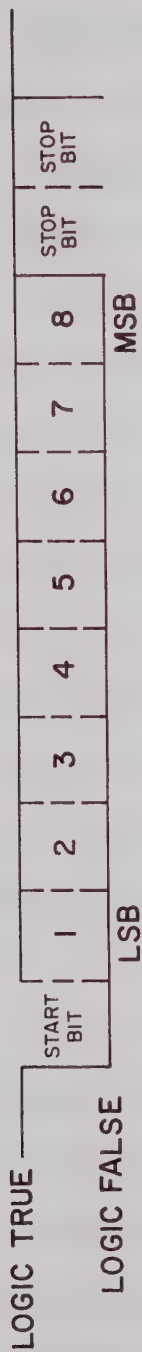
RS232 INTERFACE



TX=TRANSMIT DATA
 RX=RECEIVE DATA
 RTS=REQUEST TO SEND
 CTS=CLEAR TO SEND

FIGURE 19-16

ASYNCHRONOUS DATA FORMAT



-15V $\angle$ LOGIC TRUE $\angle$ -3V	-12V TYPICAL
+3V $\angle$ LOGIC FALSE $\angle$ +15V	+12V TYPICAL

FIGURE 19-17

In addition to the data bits, a parity bit may be added between the last data bit and the first stop bit. The parity bit is selected so the number of data bits which are logic true (1) is even or odd, depending on which parity is selected. The RS232-C interface to the 660 always uses 8 bits. When the hexadecimal switches on the Executive Board indicate that no parity is desired, or when a binary format I/O is in progress, the 8 bits with no parity mode is used. In all other cases the 7 bits plus parity bit mode is used.

A hardware handshake is provided on the RS232-C interface using the request to send (RTS) and clear to send (CTS) lines. The receiver asserts RTS when it is ready to receive data. When the CTS input to the sender is asserted, usually because it is tied to the receiver's RTS line, the sender may output data.

In the 660, the CTS line is connected through a resistor to the logic true voltage level (-12 volts). If the user's application does not require the use of this handshake signal, it need not be connected.

The RTS output of the 660 is always asserted. Handshaking of the data sent to the 660 is provided under software control. If commands are being sent to the 660 over the RS232-C interface, the sender should wait for an ACK or a NAK char-

acter before sending the next command character. (See "Acknowledging Commands," Section 19.2, Paragraph C.) When data is being input to the 660, the sender must wait for a ready character SYN (control V) from the 660 before inputting each block of data, with a block being the number of characters specified by the blocksize. On output, the 660 will wait for a SYN (control V) to be input before outputting each block. Since it may not be necessary to use this software handshake on output, either because the CTS line is used or because the receiver is a fast device, the wait for ready character may be turned off by entering the sequence 60 SET DEF AUX. After completion, the subsequent data outputs on the RS232-C interface will begin as soon as the 660 is ready to output the data. The wait for SYN (control V) is not used when outputting a status byte or for any output initiated by pressing the AUX button.

B. IEEE-488

1. Devices and Interface Lines

The IEEE-488 interface provides a means of communication among several devices in the laboratory situation. The interface is usually controlled by a device which is the bus controller. While more than one device on the bus may be capable of being controller, only one controller may

be active at any time. The remaining devices on the bus may be set up by the controller to be talkers or listeners. The programming for the controller should include information about the capabilities for each device, whether the device is capable of being a talker, listener, or both.

2. Hardware Overview

The IEEE-488 interface consists of 16 lines, 8 of which are data lines, 3 lines which are handshake signals (byte transfer control), and 5 lines which are interface management signals. See Figure 19-18. The data lines which make up the 488 data bus, DI01 to DI08, are used to pass both data and bus commands. The attention line (ATN) determines how the data lines are to be interpreted. If ATN is asserted, the data lines are interpreted as data usually being sent from a talker to one or more listeners. If ATN is not asserted, the data lines are interpreted as bus commands being sent from the controller to all other devices on the bus. When ATN is asserted by the controller, all devices must clear the bus within 200 nanoseconds.

One of the main features of the IEEE-488 interface is the unique handshake provided by the 3 transfer control signals. The 3 transfer signals are data available (DAV), not ready for data (NRFD), and not data accepted (NDAC). In any byte transfer, the source controls the DAV line and the

TYPICAL IEEE-488 BUS CONFIGURATION

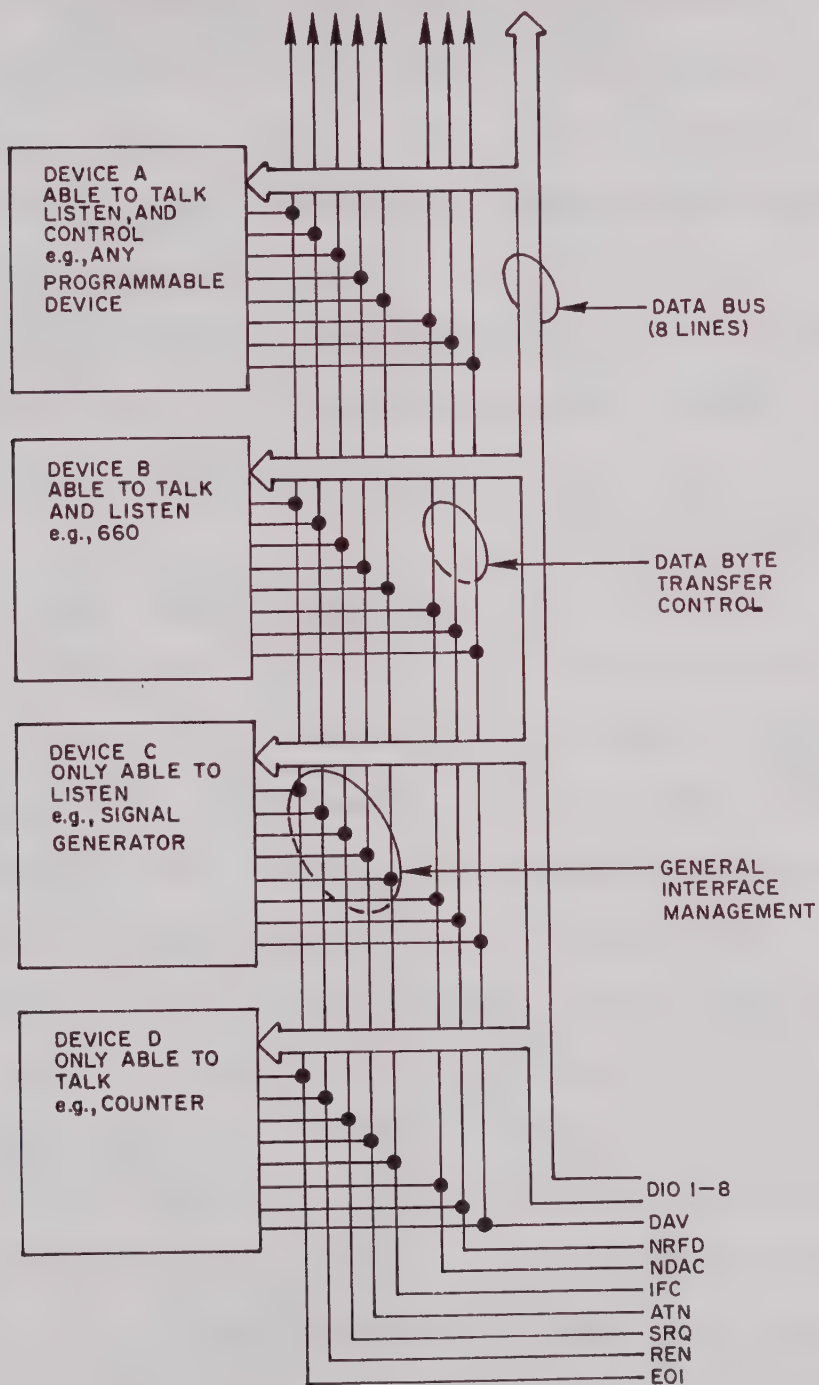
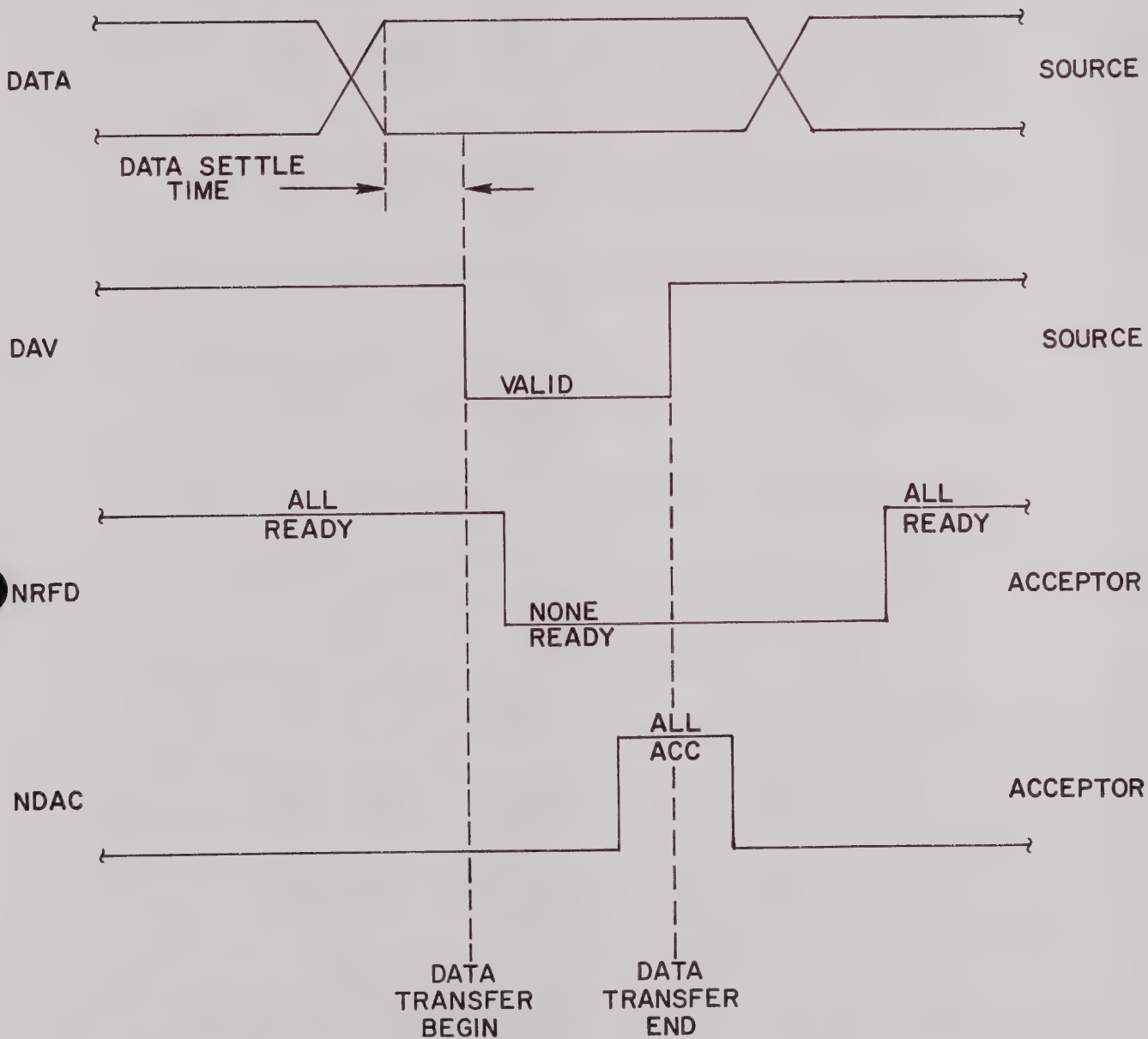


FIGURE 19-18

acceptors control the NRFD and NDAC lines. While the source is usually a talker and the acceptors are usually listeners, this is not always the case. For example, in serial polling the controller interrogates the devices on the bus. This operation requires information to be sent by the polled device. That device is a source of information even though it is a listener. All byte transfers over the data lines, data and bus commands alike, must be performed in conjunction with the source-acceptor handshake.

Figure 19-19 illustrates a typical byte transfer between a source and one or more acceptors. The asserted or true state of all signals on the 488 bus corresponds to a voltage level less than 0.8 volts and the false state corresponds to a voltage level greater than 2.0 volts. The acceptors assert NDAC, while the source indicates that data is not available. The source places a byte of data on the data lines and waits a minimum of 2 microseconds for the data to settle. When all the acceptors are ready as indicated by a false value of the NRFD line, the source starts the data transfer by asserting DAV. The acceptors then assert NRFD and begin copying the byte from the data lines into their internal buffer. As each acceptor completes the data transfer, it drives NDAC to its false level.

IEEE-488 INTERFACE
SOURCE AND ACCEPTOR HANDSHAKE



0 VOLTS = LOGIC TRUE
5 VOLTS = LOGIC FALSE

FIGURE 19-19

As long as any acceptor is asserting NDAC, the line remains low. Therefore, the data transfer rate is determined by the slowest device taking part in the transfer. When the last acceptor receives the byte, NDAC is no longer asserted. The source, sensing that the byte has been accepted by all, drives DAV to the false level and begins changing the data lines for the next byte transfer. When DAV goes false, the acceptors drive NRFD to the false state and the source may begin the next byte transfer.

The end or identify line (EOI) may optionally be used by a talker to indicate that the current byte is the last byte of the transfer. When the 660 is a talker, EOI is asserted as the last byte of the transfer is output. When the 660 is a listener and a data buffer input is in progress, asserting EOI will terminate the input. For example, the 660 will assume no more data is forthcoming and

will interpret subsequent bytes as remote commands. When remote commands are entered via the IEEE-488 interface, that is a data transfer is not taking place, the EOI line is ignored.

The EOI signal assumes the meaning IDENTIFY when the controller asserts EOI and ATN simultaneously as part of the parallel polling sequence. The controller MUST NOT parallel poll with a 660 on the bus.

The remaining three interface lines provide additional communication between the controller and other devices on the bus. When the remote enable line (REN) is asserted, devices may respond to commands from the interface. The REN line is ignored by the 660 except in connection with the GTL command. Interface clear (IFC) is used by the controller to clear all use of the interface. All devices must respond within 100 microseconds. The service request line (SRQ) may be asserted by a device to indicate to the controller that service is required.

3. Introduction

The 660 implements the 1975 IEEE-488 specification. It is assumed that the user is familiar with the terms and nomenclature associated with the 488 bus. This manual is not intended to teach the user about the bus, but rather to clarify the software implementation which is not covered in any IEEE-488 specification.

Users interested in the controller mode of operation are advised to read the short section on no controller operation, as well.

a. Operation Without a 488 Bus Controller - This mode of operation is primarily for use with the 160 Data Recorder Adapter when the 660 and 160 are the only devices on the bus. This mode can also be used for control and data transfer by another device as well.

When the 660 hex switches are set for NO CONTROLLER, the 660 will make itself a listener on power up. If it required to talk, it will make itself a talker for the duration of the transfer and then return itself to a listener again. Whatever the 488 environment is set to in the software, SRQ's will not be issued. The 660 always concludes 488 output by asserting EOI with the last byte.

b. 660 Hardware Setup

The details of the settings of the hexadecimal switches mentioned above are explained in Section 19-2. For simplicity, the controller mode maybe selected by setting switch BE1 to 0. The 488 address has no meaning in the NO CONTROLLER mode.

If the settings of these switches are changed while the 660 is on, the 660 must be reset (SYS RST) to make the changes take effect. The switch settings are read at reset/power up only.

c. Output Initiation from the 660 via the Front Panel -

As mentioned above, the 660 will make itself a talker when required. The user may require the 660 to talk by use of the DISK pushbutton in the CALCULATION CONTROL group. When this button is depressed following a SET, RECALL, or CLEAR, the 660 must talk over the 488 bus.

The format of the output is a 15 character string with an EOI on the last character, namely:

SET :	S	
RECALL :	R	14 character entry/recall field
CLEAR :	Z	
	1	2 - 15

Two other pushbutton sequences also require the 660 to talk over the 488 bus:

1. AUX*	See Section 19.2
2. AUX*, PLOT	See Section 19.2
PLOT CAL	

*Requires previous settings of DEF AUX.

d. Output Initiation from 660 via Remote Control Commands -

The 660 powers up as a listener to listen for remote control commands. Section 19.2 describes front panel buttons and switches and their remote control commands and describes the additional commands available only over the RS232 or IEEE-488 interfaces.

Two methods exist for getting the 660 to talk via these remote control commands:

1. Pushbutton Emulation - A device on the bus may be used to emulate a user depressing the pushbutton sequences previously mentioned. Section 19.2 illustrates all the remote commands associated with front panel controls. For convenience, the commands to emulate the pushbuttons are repeated below.

<u>Pushbutton</u>	<u>Remote Control Command</u>
SET	S
RECALL	R
CLEAR	Z
DISK	Y4
PLOT	00
PLOT CAL	01
AUX	02

For example, if the 660 receives over the IEEE-488 (or RS232) interface the remote control sequence: S Y4, (SET, DISK) the 660 will:

- 1) place an S in the first location of the output buffer,
- 2) copy the 14 characters currently in the entry/recall field into the output buffer locations 2 -> 15, and
- 3) become a talker on the IEEE-488 bus and issue the 15 characters over the bus, with an EOI on the last character, assuming there is a listener willing to accept these 15 bytes.

2. Buffered I/O Output Command (?) - The output over the IEEE-488 command (?) is only receivable from the IEEE-488 or RS232 interfaces. Regardless of which interface issues the command sequence ?n, the 660 will become a talker and output the data in the buffer n over the IEEE-488 bus. The buffer numbers indicated

by n are described in Section 19.3. The details of buffered I/O are described in Section 19.3.

e. Operation with a 488 Bus Controller - This mode of operation is useful for controlling the 660 via the 488 bus. It is the only mode that will allow more than two devices to be connected to the bus without confusion. It is the only mode in which the 660 will respond to bus commands such as untalk, unlisten or serial poll. However, if the 160 and the 660 are to be the only devices on the bus and no external control is desired, a controller will serve no purpose. For many sequential control applications controller mode will not be necessary since the 660 will listen for commands without a controller.

If the 660 is informed via the hex switches that there is a bus controller on the 488 bus, it will assume that it must be given permission to use the bus. At power up, it is neither listener, nor talker. If addressed by the controller to talk or listen it will remain in that state until the controller changes its assignment.

The controller must be able to find out when the 660 would like to use the bus or is finished using the bus. The 660 leaves this information in the serial poll register. The content of the serial poll register is the serial poll status byte. The controller can get this byte at any time by serial polling the 660. If the 488 environment is set so that updating the serial poll register issues a service request (SRQ), the 660 will update the serial poll register and turn on bit 6 of the serial poll status byte. This bit is the SRQ bit, its presence should interrupt the controller. When the 660 issues an SRQ, it will wait for the controller to serial

poll. This ensures that the controller will see every serial poll status byte before the 660 takes any further action. When the 660 is serial polled, the SRQ bit is removed from the serial poll status byte.

The 660 updates the serial poll register whenever the I/O is begun or finished over the 488 bus or when a command received over the 488 bus is unacceptable. The user may enable updates on other conditions and the issuance of SRQ's. For more information, see Appendix 19.5, Setting the 488 Environment. For the definition of the bit patterns that the 660 places in the serial poll register, see Appendix 19-5, Decoding the 660's Serial Poll Status Byte.

f. Controller Limitations - Beware of the following when using the controller:

1. The controller must not parallel poll with a 660 on the bus! The hardware used to implement the 488 bus in the 660 will not properly decode a parallel poll. The 660 response is unpredictable. Also, because of this, the parallel poll configure command is no longer recognized.

2. The controller must not serial poll when there is valid data on the bus that has not been accept by all listeners. Some controllers automatically wait for the DAC line (or $\overline{\text{NDAC}}$) to go high. This wait is necessary becuae the device that is serial polled must place its serial poll status byte on the data lines. It is by definition the only talker and the controller is the only listener. If data were valid on the bus and not accepted when the serial poll

active state was entered, that byte of data is lost. After the serial poll, the 660 is neither talker nor listener.

3. If the controller issues a GO TO LOCAL (GTL) command to the 660, the 660 will respond as if the 660 command 03 (CRT ONLY) had been sent over the bus: it will reset its I/O drivers. This will terminate any I/O over either the 488 or the RS232 interfaces. When the I/O drives are reinitialized, the serial poll register will be updated with a byte to this effect. The 488 environment as set in the SRQ mask is not changed by the I/O reset. After the I/O drivers have been reset, whether by a GTL or an 03, the controller must remotely enable the 660. Some controllers do this automatically as part of a high level language write statement.

g. Hardware Setup - The settings of the 660 internal hex switches are explained in Section 19-2. As shown in Figure 19-1 an example of correct settings of these switches (BC1, BE1, BG1, BJ1) would be:

SWITCH	EXPLANATION
BC1	Spare
BE1	9
BG1	C
BJ1	No effect on 488 Bus

This would set the 660 for 488 address 7, controller mode, and even parity on the RS232 interface.

Note that switch BGl sets two bits of the 488 address and selects RS232 parity. To maintain the proper address, switch BGl should be set for either C, D, or E to select even (shown), odd, or no parity on the RS232 interface.

The 488 address setting and the controller present bit must be correctly set for the 660 to accept addressed bus commands such as talk 7.

If the settings of these switches are changed while the 660 is running, it must be reset (SYS RST) for the changes to take effect. These switches are only read at reset/power up.

h. Software Setup - As mentioned previously, the user may enable optional updates of the serial poll register and/or the user may enable SRQ issuing on each update. Conditions that affect the 488 bus (I/O Request, I/O Complete, NAK) always update the serial poll register. For more information see the Appendices, Setting the 488 Environment, and Decoding the 660 Serial Poll Status Byte. If a controller is used that cannot be interrupted during a write statement, read the paragraph, Setting the 488 Environment.

The only other software setup required is that the 660 be remotely enabled. As previously mentioned, some controllers do this automatically as part of a write statement.

C. J114 Control Connector

1. Control Inputs

Seventeen external control inputs are provided on the parallel interface connector (see Pin Assignments J114). To use these signals, which are equivalent to the similarly labeled front panel pushbuttons, the user must assert the desired line and pulse the input control data strobe pulse. In addition, all external control data lines not being used must be grounded. The lines must continue to be asserted until the 660 outputs a pulse on the Data Accept line. The one exception to this handshake is the system reset line. When this line is asserted, the 660 is reset immediately and no data strobe pulse is required.

2. Miscellaneous Output Signals

The miscellaneous outputs available on the parallel interface connector follow.

Block Sync Pulse - Pulsed high as an average is calculated on non-redundant data in signal enhancement mode. For example, the entire input buffer contains different data since the previous block sync pulse.

3. J113 Parallel A/D Input - Little discussion has taken place regarding the A/D interface because unlike the other interfaces, the A/D interface can not be used to access the internal data buffers. The digital data entering the input buffer may be viewed, or the internal A/D's may be replaced by inputting digital time domain data into this interface. All signals are TTL. The true state is a high unless the signal name has a bar over it.

Refer to Figure 19-19. When the A/D interface is used to output data from the internal A/D's, the data is presented on the 12 most significant bits of each channel's A/D data bus (bits 15 to 4). The data from the A/D's is in two's complement format and is interpreted as a fraction of the full scale indicated by the front panel input attenuator controls. This fraction can range from -1 (100000000000) to $1-2^{-12}$ (011111111111). When the internal A/D's are used, bits 0 to 3 are tied to zero on the input to the input buffer. The AEOC line is pulsed high when the conversion is complete. As new data is presented on the data lines, AEOC may be used as a data available signal. This is true whether or not an external sampling signal is used.

To use an external sampling rate, the front panel FREQ/ORDERS switch must be placed in the ORDERS position and a sampling waveform must be input to the associated BNC connector. This waveform is usually a sine wave with a frequency 2.56 times the highest frequency of interest. In this case the frequency range switch selects the anti-aliasing filter to be used. The input sampling waveform must have a peak-to-peak voltage of at least 1 volt and less than 10 volts.

The A/D conversion cycle is started on the positive to negative transition through zero of the external sampling signal. The end of conversion is indicated by the

FIGURE 19-20
A/D INPUT DATA (FOR REAL DATA) NO DRT

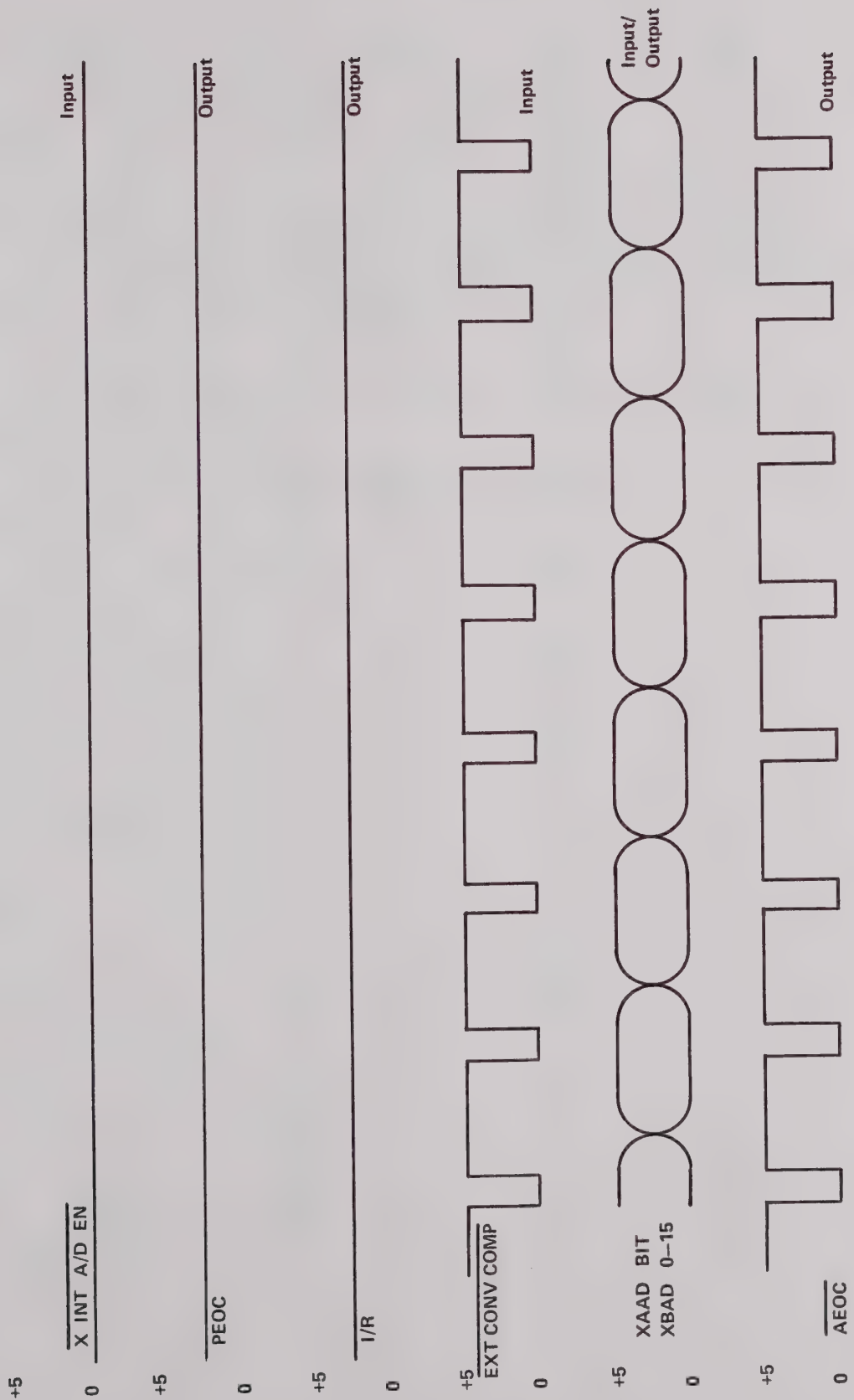
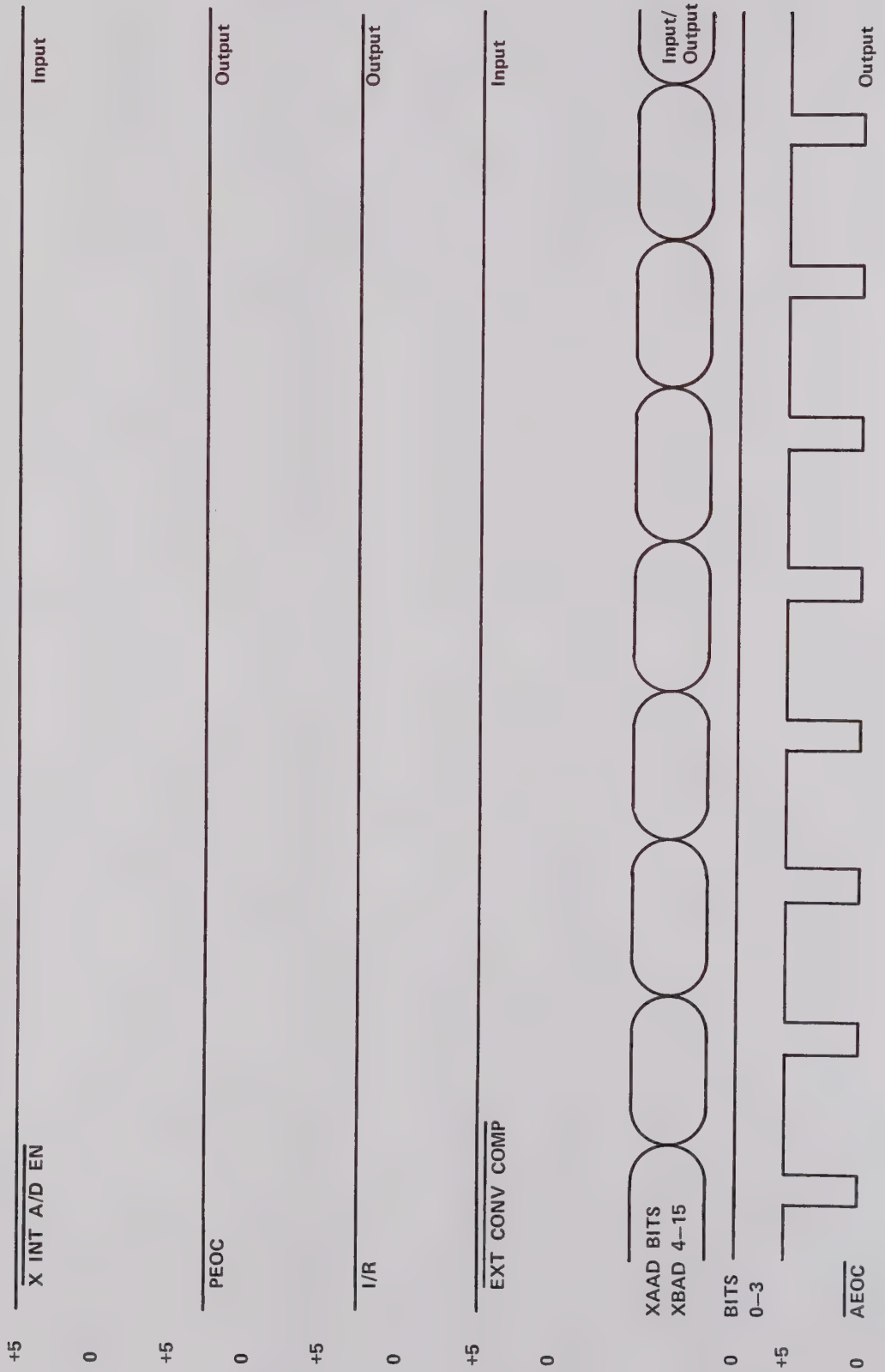


FIGURE 19-20 (Cont.)
A/D OUTPUT DATA (FOR REAL DATA) NO DRT



AEOC signal.

To enter the external time domain data through the A/D interface, the following steps must be taken.

1. The external A/D enable line must be held low.
2. The data for channels A and B must be presented on the A/D bus in two's complement form with the most significant bit at 15. This A/D data is interpreted as a fraction of the full scale indicated by the input attenuator control setting.
3. External conversion complete must be pulsed low to indicate when the next data word is available at the A/D connector.
4. If the data for a channel is less than 16 bits wide, the unused bits should be tied low.

19.5 Appendix

A. Pin Assignments

1. IEEE-488 (1975), J111

<u>Pin</u>	<u>Mnemonic</u>	<u>Comments</u>
1	DI01	Data Line 1
2	DI02	Data Line 2
3	DI03	Data Line 3
4	DI04	Data Line 4
5	EOI	End Or Identify
6	DAV	Data Available
7	NRFD	Not Ready For Data
8	NDAC	Not Data Accepted
9	IFC	Interface Clear
10	SRQ	Service Request
11	ATN	Attention
12	SHIELD	
13	DI05	Data Line 5
14	DI06	Data Line 6
15	DI07	Data Line 7
16	DI08	Data Line 8
17	REN	Remote Enable
18	GRD-1	Ground, (6)
19	GRD-2	Ground, (7)
20	GRD-2	Ground, (8)
21	GRD-2	Ground, (9)
22	GRD-2	Ground, (10)
23	GRD-2	Ground, (11)
24	GRD-2	Ground, LOGIC

NOTE: 'Ground, (n)' refers to the signal ground return of the referenced contact.

2. RS232-C, J112

<u>Pin</u>	<u>Mnemonic</u>	<u>Comments</u>
3	TD	Transmit Data (from 660)
2	RD	Receive Data (to 660)
4	RTS	Request to Send (output)
5	CTS	Clear to Send
8	RLSD	Data Carrier Detect
7	GRD-3	Data Common
1	CHASSIS GRD	

3. Parallel A/D, J113

<u>Pin</u>	<u>Mnemonic</u>	<u>Comments</u>
1	GRD-5	
26	XBAD 0	External B CH A/D Data 0
2	XBAD 1	1
27	XBAD 2	2
3	XBAD 3	3
28	XBAD 4	4
4	XBAD 5	5
29	XBAD 6	6
5	XBAD 7	7
30	XBAD 8	8
6	XBAD 9	9
31	XBAD 10	10
7	XBAD 11	11
32	XBAD 12	12
8	XBAD 13	13
33	XBAD 14	14
9	XBAD 15	15
34	XAAD 0	External A CH A/D Data 0
10	XAAD 1	1
35	XAAD 2	2
11	XAAD 3	3
36	XAAD 4	4
12	XAAD 5	5
37	XAAD 6	6
13	XAAD 7	7
38	XAAD 8	8

NOTE: All signals are TTL level. The true state is high, unless the signal name is barred.

3. Parallel A/D, J113 (Con't.)

<u>Pin</u>	<u>Mnemonic</u>	<u>Comments</u>
14	XAAD 9	External A CH A/D Data
39	XAAD 10	
15	XAAD 11	
40	XAAD 12	
16	XAAD 13	
41	XAAD 14	
17	XAAD 15	
42	XINT AD EN	External A/D Enable
18	PEOC	Pseudo End of Conversion
43	I/R	Imaginary/Real Point
19	AEOC	A Channel End of Conversion
44	EXT CONV COMP	External Conversion Complete
20		

50

GRD-4

NOTE: All signals are TTL level. The true state is high, unless the signal name is barred.

3. Parallel A/D, J113 (Con't.)

<u>Pin</u>	<u>Mnemonic</u>	<u>Comments</u>
14	XAAD9	External A CH A/D Data 9
39	XAAD10	10
15	XAAD11	11
40	XAAD12	12
16	XAAD13	13
41	XAAD14	14
17	XAAD15	15
42	XINT AD EN	External A/D Enable
18	PEOC	Pseudo End of Conversion
43	I/R	Imaginary/Real Point
19	AEOC	A Channel End of Conversion
44	EXT CONV COMP	External Conversion Complete
50	GRD-4	

4. Control Interface, J114

<u>Pin</u>	<u>Mnemonic</u>	<u>Comments</u>
59	DATA ACC	Data Accept
28	BLK SYNC PULSE	Block Synchronization Pulse
60	INPUT PULSE	Input Control Data Strobe Pulse
29	DISP ADV	Display Advance
61	HOLD	External Hold
30	ARM	External Arm
62	SYS RESET	System Reset
63	START	External Start
32	STOP	External Stop
64	CONT	External Continue
1		External Control Data 11
33	PLOT	External Plot
2	PLOT SET-UP	External Plot Set-up
34	AUX	External Aux
3	CRT ONLY	External CRT Only
35		External Control Data 6
4	DISPLAY MEMORY	External Display Memory Store
36		External Control Data 4
5		3
37		2
6		1
38	SPARE	
7	SPARE	

NOTE: ALL SIGNALS ARE TTL LEVEL. THE ASSERTED STATE IS A TTL HIGH, UNLESS THE SIGNAL NAME IS BARRED, IN WHICH CASE, THE ASSERTED STATE IS A TTL LOW.

19.5 Appendix

B. ASCII Character Set

ASCII CHARACTER SET (7-BIT CODE)

M.S. CHAR	0	1	2	3	4	5	6	7
L.S. CHAR	000	001	010	011	100	101	110	111
0 0000	NUL	DLE	SP	0	@	P	'	p
1 0001	SOH	DC1	1	1	A	Q	a	g
2 0010	STX	DC2	"	2	B	R	b	r
3 0011	ETX	DC3	#	3	C	S	c	s
4 0100	EOT	DC4	\$	4	D	T	d	t
5 0101	ENQ	NAK	%	5	E	U	e	u
6 0110	ACK	SYN	&	6	F	V	f	v
7 0111	BEL	ETB	'	7	G	W	g	w
8 1000	BS	CAN	(	8	H	X	h	x
9 1001	HT	EM	)	9	I	Y	i	y

The characters in Columns 0 and 1 can be generated on most terminals by holding the CNTRL key and depressing the corresponding character in Columns 4 and 5, respectively. Example, BEL = CNTRL/G. DC1 = CNTRL/Q.

ASCII CHARACTER SET (7-BIT CODE)

M.S. CHAR	0	1	2	3	4	5	6	7
L.S. CHAR	000	001	010	011	100	101	110	111
A 1010	LF	SUB	*	:	J	Z	j	z
B 1011	VT	ESC	+	;	K	[	k	{
C 1100	FF	FS	,	<	L	\	l	:
D 1101	CR	GS	-	=	M	]	m	}
E 1110	SO	RS	•	>	N	↑	n	~
F 1111	SI	VS	/	?	O	↓	o	DEL

The characters in Columns 0 and 1 can be generated on most terminals by holding the CNTRL key and depressing the corresponding character in Columns 4 and 5, respectively. Example, BEL = CNTRL/G, DC1 = CNTRL/Q.

19.5 Appendix

C. Using the 660 with SRQ and Serial Poll

1. Setting the 488 Environment

With the 660 in the controller mode (as set on the internal hex switches, see pages 19-3 to 19-7), the 660 can not make itself a talker or listener. The 660 must be instructed to be a talker or a listener by the controller. The controller serial polls the 660 for instructions and receives a serial poll status byte, contents of the serial poll register.

The following conditions always update the serial poll register:

1. Any I/O Type: Request, Completion, or
I/O Has Been Reset
2. Either NAK: Command Not Acceptable, or
I/O Must Be Reset

Other conditions may update the serial poll register. These can only be set from the interface using the SRQ mask as will be described below. The SRQ mask is also referred to as the 488 environment mask. Bit 6 of the SRQ mask controls whether or not each update of the serial poll register will issue an SRQ.

NOTE: IF SRQ'S ARE ENABLED, THE CONTROLLER
MUST BE CAPABLE OF SERIAL POLLING.

The 660 will wait to be serial polled after posting an SRQ.

Controlling Serial Poll Register Updates and SRQ's

On power up, the 660 wakes up with the SRQ mask set to 0. This means that only required conditions update the serial poll register and these updates do not cause SRQ's. The following

diagram explains the bits in the SRQ mask:

Value	128	64	32	16	8	4	2	1
Bit #	7	6	5	4	3	2	1	0

Bit 0	Update on Averager ON/OFF	1=enabled
Bit 1	Spare	
Bit 2	Update on ACK	1=enabled
Bit 3	Update on ARM ON/OFF	1=enabled
Bit 4	Update on HOLD ON/OFF	1=enabled
Bit 5	Update on PLOT ON/OFF	1=enabled
Bit 6	SRQ on every update of the serial poll word	1=enabled
Bit 7	Update on OVERFLOW ON/OFF	1=enabled

The SRQ mask may be set, recalled to the entry field, or cleared (set to zero) by the commands SWB, RWB, and ZWB. These commands may only be issued via the interfaces since no push-button corresponding to WB exists on the front panel. S, R, & Z correspond to SET, RECALL and CLEAR; WB is the function similar to the others in the CALCULATION CONTROL group.

For example, to get SRQ's only on required updates (I/O and NAKS), the controller sends the command string 64SWB. To get SRQs on required updates and averager on/off, the controller sends 65SWB. This should be interpreted as allowing averager on/off to update the serial poll register and SRQ on all updates.

Some controllers can not be interrupted by SRQ's during read and write statements, for example, the HP-9825. If this condition exists, and updates on ACKS with SRQ's enabled are desired, the 660 command output must be preceded by a "/". The slash is a one byte command equivalent to ZWB. If the "/" is omitted, the first byte of the output will pro-

duce an ACK SRQ from the 660 and the handshake will not be completed until the SRQ is responded to (serial polled). See Section 19-5. Since this controller can not be interrupted during a write, it will not serial poll until the write finishes. Therefore, the write will never finish.

For example, if this controller can not be interrupted, and if an SRQ mask of 68 has been established, the string 02 (press the AUX button) would hang. The string /0268SWB would turn off SRQ's, send the 02, and then re-establish the SRQ mask. Another solution would be having the controller output a byte at a time.

Note, that even if only one event causes updates, for example, averager on/off, other bits in the serial poll word will be correct when update occurs. That is, if the overflow bit is on in the serial poll word created by an update when the averager went off, an overflow did occur during the average even though that did not cause an update at that time.

In the above paragraph the word SRQ may be substituted for update in all cases to show what happens when bit 6 of the SRQ mask (SRQ on updates) is 1.

2. Decoding the 660 Serial Poll Status Byte

As described in the previous section, the controller may serial poll a 660 and obtain the serial poll status byte. The 660 places this byte in its serial poll register (an update) when a condition occurs that elicits a response from the controller. There are three types of conditions

that may cause a serial poll register update. The type may be decoded from bits 1 and 2 of the serial poll status word:

Bit #	7	6	5	4	3	2	1	0
-------	---	---	---	---	---	---	---	---

Bits 1 & 2 - Type of condition that causes this status byte to be created:

- 00 Event Response
- 01 I/O
- 10 Spare
- 11 Command Response

Bit 6 - Always reserved for SRQ Bit
1 = Active Service Request

All event updates are optional, as is the acknowledge command response. If updates on these conditions are desired, each must be enabled as described in the previous section.

I/O and NAK updates are not optional.

For the 660 to post a service request (SRQ) on each update, see the previous section.

An explanation of each serial poll status byte follows.

a. Event Updates

There are ten events which cause an update of the serial poll status byte. These ten are the transition to ON and the transition to OFF of the following: averager, arm, hold, plot, and overflow.

The status of each one is represented by a bit in the event type serial poll status byte. For each, 1 = ON and 2 = OFF. The status shown by each bit will be correct even if that bit did not cause the update.

The event serial poll status byte is structured as follows:

Bit #	7	6	5	4	3	2	1	0
Bit 0								- Averager ON/OFF
Bit 1 & 2								- Event type status byte
Bit 3								- Arm ON/OFF
Bit 4								- Hold ON/OFF
Bit 5								- Plot ON/OFF
Bit 6								- Reserved for SRQ bit Overflow ON/OFF*
								*Overflow is only cleared by starting the averager

Note that each condition is represented by the same bit in the status word as the bit that enables the update in the SRQ mask.

b. I/O Updates

Updates concerning the function of I/O are not optional. There is one special one:

Bit #	7	6	5	4	3	2	1	0
Bit 1 & 2								- I/O Type - I/O has been reset. Tells the controller that I/O has been terminated by CRT ONLY.
Bit 6								- Reserved for SRQ bit

The controller must send the REMOTE ENABLE to the 660 at this point. Other I/O updates follow this pattern.

Bit #	7	6	5	4	3	2	1	0
Bit 0								- 0 = Out, 1 = In
Bit 1 & 2								- I/O Type Update
Bit 3, 4, & 5								- Type of I/O: 000 = General Buffer 001 = Disk Command 010 = AUX 011 = AUX Plot 111 = Reserved, See Above
Bit 6								- Reserved for SRQ bit
Bit 7								- 0 = Request, 1 = Complete

c. Command Response Updates

There are three possible command responses:

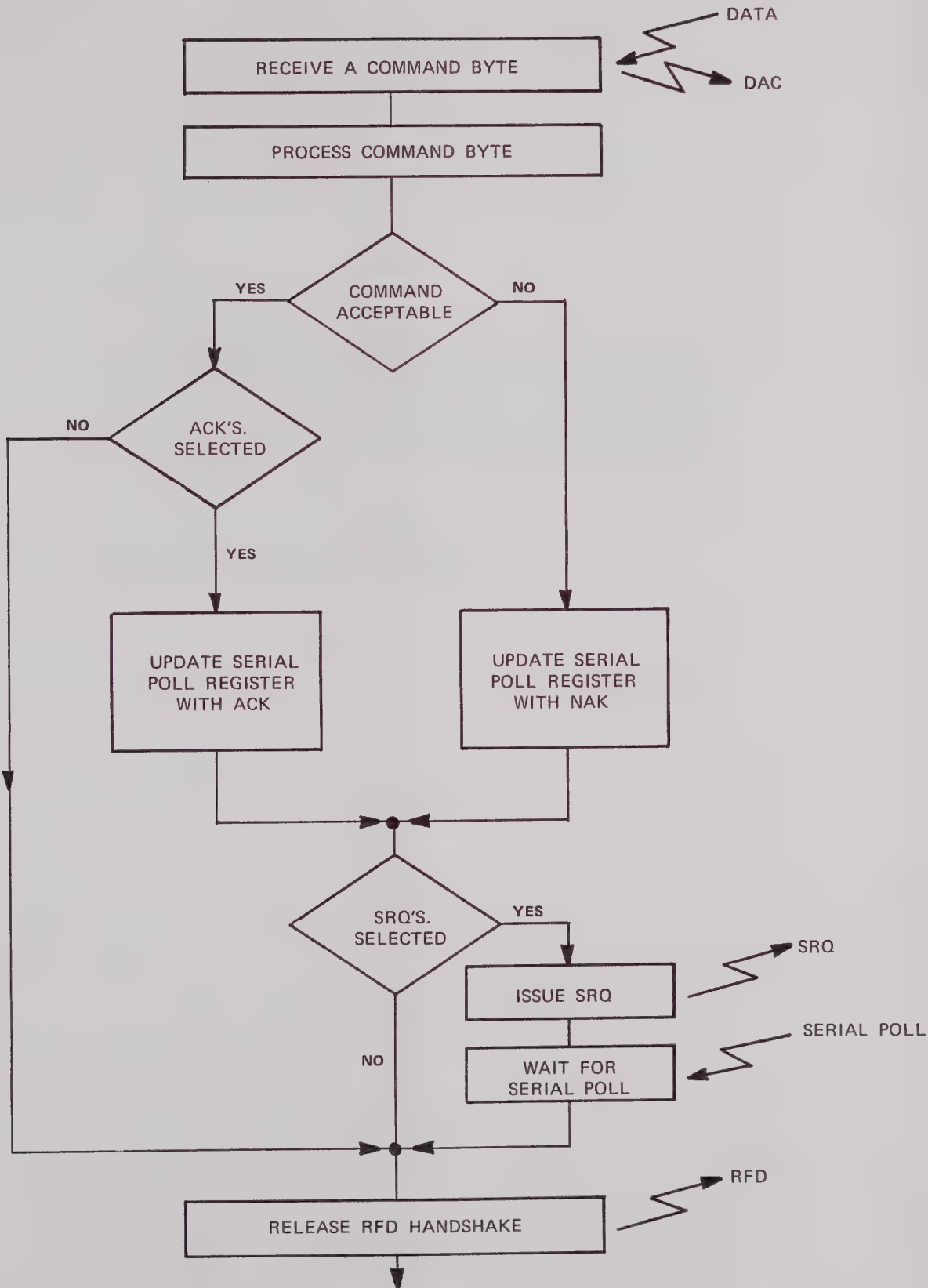
ACK:	Command Accepted:	0X000110
NAK:	Command Not Accepted:	0X000111
I/O MUST BE RESET:	I/O Must Be Reset:	0X001111

Bit #	7	6	5	4	3	2	1	0
-------	---	---	---	---	---	---	---	---

Bit 0	- 0 = ACK, 1 = NAK
Bit 1 & 2	- Command Response
Bit 6	- Reserved for SRQ bit

The ACK is optional. See the previous section to enable updates on ACKS. The Command Not Accepted NAK simply means that a command received could not be accomplished.

The I/O MUST BE RESET NAK means that everything coming in to the 660 on the 488 bus is considered invalid. This occurs if a 660 buffer is overrun. The controller response would be to send a GO TO LOCAL message and then remote enable the 660 again.



19-20. 660 RESPONSE TO COMMANDS RECEIVED OVER IEEE-488 INTERFACE

Dear Customer:

This instrument was shipped to you in a container especially designed to protect it during shipment. This container is worth approximately \$40.00 and should be saved in case the unit should have to be returned. In the event you must return this instrument and you do not have the original shipping container please pack the unit in a *double walled corrugated box* with at least *3 inches of foam packing material*.

Instruments which arrive insufficiently packed will be *liable for charges to cover the cost of replacement packing*.

Thank you,
Customer Service

WARRANTY

Nicolet Scientific Corporation warrants each instrument manufactured by it to be free from defects in material and workmanship. Our liability under this warranty is limited to servicing or adjusting any instrument returned to the factory for that purpose and to replace any defective parts thereof. This warranty is effective for one year after delivery to the original purchaser when the instrument is returned, transportation charges prepaid by the original purchaser, and when upon examination it is disclosed to our satisfaction to be defective. If the fault has been caused by misuse or abnormal conditions of operation, normal service charges will prevail. In this case, an estimate will be submitted before the work is started. Warranty returns must first be authorized by Nicolet Scientific Corporation.

All equipment not manufactured by Nicolet Scientific Corporation is subject only to the warranty provided by the supplying manufacturer.

No other warranties are expressed or implied, including, but not limited to, the implied warranties of merchantability and fitness for a particular purpose. Nicolet Scientific Corporation is not liable for consequential damages.

If this product is sold as part of a Nicolet Scientific Corporation integrated system, the above warranty shall not be applicable, and this product shall be covered only by the system warranty.

Nicolet Scientific Corporation reserves the right to make changes in the design of its instruments without incurring any obligation to make the same changes on equipment previously purchased.

CLAIM FOR DAMAGE IN SHIPMENT

The instrument should be tested as soon as it is received. If the instrument is damaged in any way, a claim should be filed with the carrier. A full report of the damage should be obtained by the claim agent, and this report should be forwarded to us. We will then advise you of the disposition to be made of the equipment and arrange for repair or replacement. Include model number, serial number, and purchase order number when referring to this instrument for any reason.

SHIPPING

If the unit fails to operate or any fault develops, the following steps should be taken:

1. Notify us, giving full details of the difficulty, and include the model number and serial number of the equipment. On receipt of this information, we will give you service data or shipping instructions.

2. On receipt of shipping instructions, forward the instrument prepaid to Nicolet Scientific Corporation. If requested, an estimate of the charges will be made before the work begins, provided the instrument is not covered by the warranty.

3. If the instrument is to be shipped, it is imperative that it be properly packaged. Where possible, use the specially designed packaging material in which the unit was delivered.

This warranty is expressly in lieu of all other obligations or liabilities on the part of Nicolet Scientific Corporation, which neither assumes nor authorizes any person to assume for it any other liability in connection with the sale of its instruments.

APPENDIX A

660 ENTRY FIELD MESSAGES AND ERROR INDICATIONS

(appear in upper left "entry field" in the annotated display)

<u>MESSAGE</u>	<u>DESCRIPTION</u>
NICOLET 660	Indicates that instrument has just been turned on.
BASEBAND DISP	Indicates that an expansion has just been cleared.
PANEL (N)	Indicates the current status of the instrument controls is panel pattern #N. (N is between 1 and 9).
CURSOR (N) XXXX	Indicates that #N cursor has been recalled. Address XXXX is the cursor location in "CELL" number, i.e., frequency element in a spectrum or sample increments in a time display.
FREQ ABSOLUTE	Indicates that the frequency reference has just been cleared.
DISP F. S. SET	Indicates that display Full Scale has just been set by explicit keyboard entry actuated by a momentary flip of either upper or lower gain switch (any 3 digit number with virtually unlimited exponents). As soon as lever "gain" switch is used again, only "preferred" numbers are employed.
<u>ERRORS</u> (reversed type)	<u>OPERATOR HAS TRIED TO PERFORM THE FOLLOWING INCORRECT OPERATION</u>
XXXX > YYYY	Enter a number <u>not</u> between the limits XXXX and YYYY.

ERRORS

OPERATOR HAS TRIED TO PERFORM THE FOLLOWING INCORRECT OPERATION

20 to 160 dB	Enter a display dB range <u>outside</u> of the allowable 20 to 160 dB limits.
20 dB STEPS	Set a display dB range to a <u>non</u> -integer multiple of 20.
NO EXPANDER	Set expansion when frequency expansion option (-2) is <u>not</u> in the instrument.
TF NOT STORED	Equalize <u>without</u> previously storing a transfer function.
NO STORED DATA	Compare or equalize <u>without</u> prior storage of data.
USE XXXX RANGE	Compare displayed function obtained on a range <u>different</u> from the stored function.
USE 1K FFT USE 2K FFT USE SIG ENH USE CORR USE PROB	Compare a function in an operating mode <u>different</u> from stored one.
VIEW FREQUENCY	Set a frequency or order reference while viewing a function <u>other</u> than frequency.
SET ORD > 0.0	Set an order reference equal or less than 0.00.
VIEW A OR B	Set an integration or differentiation operation or enter a volt-per-engineering unit scale constant while viewing a <u>two</u> channel display.
MUST VIEW A	View a channel B function when operating in a mode for which only "A" is available.

ERRORS

OPERATOR HAS TRIED TO PERFORM THE FOLLOWING INCORRECT OPERATION

MUST VIEW B	View a channel A function when operating in a mode for which only "B" is available.
TURN ON CURSOR	Perform an operation involving the cursor when it is <u>not</u> turned on.
CURSOR LIMITED	Cursor position requested does not fall on display.
ONLY 2 TRACES	Compare dual displays (that would have resulted in 4 data traces). Selected a "format" requiring 4 traces. Selected A & B channel requiring 4 traces.
RECALL, MATCH	Compare a displayed function which is <u>not</u> the same as the one stored.
OPERATION N/A	Operation not applicable to the system.
FORMAT N/A	Display format not available in current panel configuration.
FUNCTION N/A	Function not available in current panel configuration.
N/A IN XPND	The selection function is not available when the expander is active.
EXIT EQL	The equalization mode must be exited before the requested operation can be performed.

APPENDIX C
APPLICATION NOTES

Application notes follow which may be useful to
the 660 user.

CHECKSUM PROCEDURE

The following instructions will contain all of the necessary information and equipment requirements to perform the Executive and Slice prom checksums in the 660 system. Enclosed at the end of the instruction sheet is a complete Executive and Slice prom checksum listing.

Equipment Required:

- 1) Small wire jumper
- 2) Lear Seigler Adm-3A terminal or equivalent terminal with RS-232C port.
- 3) Read only memories 100-SP-7895-162 thru 165 located on the Slice Display board must be Rev. C or Rev. AA.

The prom checksum is a useful troubleshooting tool in the event that the 660 is completely inoperative or it will only operate in certain modes or functions. However, there are some basic assumptions that must be made in order to use this troubleshooting aid effectively. They are the following:

- 1) The Memory Data Bus (MDB) and Memory Address Bus (MADDR) must be operative and functional.
- 2) The 6800 microprocessor must be able to access 660BUG located in prom on the Slice Display board.
- 3) The 8K Memory bank enables located on the Executive Processor must be functional.
- 4) The decoders and address buffers located on the Slice boards that access the executive proms must be functional.

There is a...

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The Executive Prom Checksum listings provide the following information:

- 1) Prom #
- 2) Address Range- address range that is allotted for a particular prom in the 6800 Memory Map. Hexademical format.
- 3) MS/LS- Most and least significant byte which will be directly related to the HI CKSM and LOW CKSM.

M= HI CKSM

L= LOW CKSM

- 4) Bank en- 8K bank enable used to access a particular prom.
- 5) Board- which board the prom is located on.
- 6) Location- the exact location of a prom on a board.

The revision of each prom in the system must be known prior to the start of obtaining the checksums. Each prom should have a prom number followed by a revision letter. The revision letter can then be checked against the checksum to indicate whether the prom is good or not.

The following procedure will set the 660 up to obtain the Checksums:

- 1) Attach the terminal to the RS-232 (J112) connector on the Rear panel of the 660.
- 2) Attach the small wire jumper from J5-49 to the nearest ground testpoint on the Slice Display Board.
- 3) Apply power to the 660 and the terminal and depress the "SYS RESET" located to the left of the power switch on the 660. The following character ">" should appear on the terminal.

1941

1941 - 1942

1941 - 1942

1941

1941 - 1942

1941 - 1942

1941

1941 - 1942

1941

1941

1941 - 1942

1941 - 1942

1941

1941 - 1942

1941 - 1942

1941 - 1942

1941 - 1942

1941 - 1942

1941 - 1942

1941 - 1942

4) Depress the letter "K" on the terminal and the terminal display should appear as follows:

> K

START

5) Enter the first four digit number in the ADDR RANGE via the terminal. The terminal display will appear as follows:

> K

1st 4 digit number

START _ _ _ _ _ ← of ADDR RANGE

HI CKSM= _ _ _ _ _ (checksum for MOST significant byte prom (M)).

LOW CKSM= _ _ _ _ _ (checksum for LEASE significant byte prom (L))

Notice that HI CKSM= _ _ _ _ _ and LOW CKSM= _ _ _ _ _ will appear on the terminal display followed by a 4 digit number in hexademical format. This is the checksum for the proms.

M=HI CKSM L=LOW CKSM

example: Checksum for prom numbers 102E and 103E. The following will appear on the terminal display after Step 5:

K

START 8000

HI CKSM-167E

LOW CKSM-1CDB

The HI CKSM = 167E corresponds to the checksum of the 102E prom and LOW CKSM = 1CDB corresponds to the checksum for 103E.

6) Repeat Steps 4 and 5 until all prom checksums are checked and note which proms do not verify with the checksum listings.

1. 12. 1971

2.

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1. 12. 1971

The same checksum procedure, with some modifications, can be used to find the checksums for the FFT/AVG SLICE PROMS, the DISPLAY SLICE PROMS and the CONSTANT PROMS.

*This checksum procedure will not find problems with proms that are speed related or intermittent.

- 1) Remove prom # 100-SP-7895-102 located at AB1 of the SLICE DISPLAY board.
- 2) Install the prom that is thought to be bad in location AB1 of the Slice Display Board.
- 3) Follow steps 1 thru 4 that are used for checking the executive proms.
- 4) Enter the four digit number 8000 via the terminal. The terminal display will appear as follows:

>E

START 8000

HI CKSM= _ _ _ _ LOW CKSM= _ _ _ _

The only number to be concerned with is the "HI CKSM= _ _ _ _."

The four digit number following "HI CKSM=" should correspond to the checksum for the prom that was installed in location AB1 of the Slice Display Board.

- 5) Reinstall the 100-SP-7895-102 prom at location AB1 of the Slice Display Board.

CHECKSUMS FOR CONSTANT PROMS

100-SP- 7895-92	<u>Rev.</u> A	<u>Checksum</u> 0A91
93	A	1F50
94	A	1E37
95	A	1DEB
96	A	20F1
97	A	200F
98	A	1E85
99	A	1DC3
100	A	17AE
101	A	1482

CHECKSUMS FOR FFT/AVG SLICE PROMS

100-SP-
7895-56

	<u>Rev.</u>	<u>Checksum</u>
	BA	Ø8ØA
57	BA	191C
58	BA	ØE69
59	BA	Ø82B
60	BA	ØBDC
61	BA	Ø416
62	BA	Ø84A
63	BA	Ø7BD
64	BA	11EC
65	BA	Ø854
66	BA	13ED
67	BA	1389
68	BA	ØBF4
69	BA	1BFE
70	BA	ØFFD
71	BA	Ø583
72	BA	ØD43
73	BA	Ø896
74	BA	ØAF8
75	BA	ØC87
76	BA	ØCA3
77	BA	Ø7ED
78	BA	ØD5A
79	BA	ØCD8

CHECKSUMS FOR FFT/AVG SLICE PROMS

100-SP-
7895-56

	<u>Rev.</u>	<u>Checksum</u>
	D	07A3
57	D	1893
58	D	0DBF
59	D	07EE
60	D	0B58
61	D	03F5
62	D	0832
63	D	07A5
64	D	117C
65	D	0795
66	D	1296
67	D	11F2
68	D	0D11
69	D	0DOA
70	D	1116
71	D	06C9
72	D	0EA8
73	D	0A87
74	D	0C37
75	D	0DE2
76	D	0DB5
77	D	08F3
78	D	0EDA
79	D	0DB1

CHECKSUMS FOR DISPLAY SLICE PROMS

100-SP- 7895-80	Rev. G	Checksum 0A09
81	G	1524
82	G	0F25
83	G	053E
84	G	0917
85	G	03B3
86	G	06B9
87	G	0885
88	G	0D33
89	G	0594
90	G	0A71
91	G	0E2D

CHECKSUMS FOR FFT/AVG SLICE FRAMS100-SP-
7895-56Rev.
AAChecksum
Ø8ØA

57

AA

191C

58

AA

ØE69

59

AA

Ø82B

60

AA

ØBDC

61

AA

Ø416

62

AA

Ø84A

63

AA

Ø7BD

64

AA

11EC

65

AA

Ø856

66

AA

13FØ

67

AA

12B7

68

AD

ØBA1

69

AD

1B95

70

AD

ØFA2

71

AD

Ø526

72

AD

ØCEA

73

AD

Ø84B

74

AD

ØAAD

75

AD

ØC3Ø

76

AD

ØCØ5

77

AD

Ø73C

78

AD

ØDØ7

79

AD

ØC6A

CHECKSUMS FOR FFT/AVG SLICE PROMS

100-SF-
7895-56

	<u>Rev.</u> AA	<u>Checksum</u> 080A
57	AA	191C
58	AA	0E69
59	AA	082B
60	AA	0BDC
61	AA	0416
62	AA	084A
63	AA	07BD
64	AA	11EC
65	AA	0856
66	AA	13F0
67	AA	12B7
68	AA	0C11
69	AA	1C08
70	AA,AC	1012,1012
71	AA	0590
72	AA	0D62
73	AA,AC	08C0,08C3
74	AA	0B07
75	AA	0C9A
76	AA	0C64
77	AA	07AA
78	AA,AB	,0D61
79	AA	0CD2

100-SP-1895
 S RANGE
 S FM
 D TION:

102 8000-83FF M 8K-4 DISP ABL	103 8000-83FF L 8K-4 DISP ADL	104 8400-87FF M 8K-4 DISP AFL	105 8400-87FF L 8K-4 DISP AHL
REV.	REV.	REV.	REV.
CHKSUM	CHKSUM	CHKSUM	CHKSUM
E AA BA CA EA	E AA BA CA EA	E AA BA CA EA	E AA BA CA EA
167E 166F 1960 195F 1541	1CDB 1D53 1CED 1DOF 18E2	OD1B OCFB OFEF OFBA 1690	1131 1182 14BF 14EB 1D01

106	107	108	109
8800-8BFF	8800-8BFF	8C00-8FFF	8C00-8FFF
M	L	M	L
8K-4	8K-4	8K-4	8K-4
DISP	DISP	DISP	DISP
BA1	BC1	BD1	BG1
REV.	REV.	REV.	REV.
E	E	E	E
J	H	AA	AA
AA	J	BA	BA
AR	AA	BF	BF
BA	AB	CA	CA
CA	BD	EA	EA
EA	EA		
CHKSUM	CHKSUM	CHKSUM	CHKSUM
190F	1D34	1A5C	1C88
190C	1D35	1ABD	1A6D
194A	1D27	19AC	1D33
1947	1CC3	19A9	1D39
18A8	1CB5	1A50	1D60
173B	1CBF	1567	1A83
153A	1D6C		
	19FA		

100-SP-7895
 RANGE
 S
 FM
 D
 TION

110	111	112	113
9000-93FF	9400-97FF	9400-97FF	9400-97FF
L 8K-4 DISP AA10	M 8K-4 DISP AG10	L 8K-4 DISP AG10	M 8K-4 DISP AG10
REV.	REV.	REV.	REV.
E AA BD CA EA	E M AA AF BD CA EA	E AA BA CA EA	E AA BA CA EA
CHKSUM	CHKSUM	CHKSUM	CHKSUM
148F 14B3 1365 1362 1841	1831 182B 17A6 17A0 17C2 17D0 1B89	17D8 17EE 18E6 194E 1958	1B3C 1B30 1D3D 1C4C 1D88

100-SF-1895

RANGE

FN

D
TION

114
9800-9BFF

M
8K-4
DISP
AJ10

REV.

CHKSUM

E
F
AA
PA
CA
CD
EA

165F
1680
16DD
1775
183B
1845
18E8

115
9800-9BFF

L
8K-4
DISP
BB10

REV.

CHKSUM

F
AA
BD
CA
CD
EA

1A8D
1A34
1D66
1C6F
1C77
1F3F

116
9C00-9FFF

M
8K-4
DISP
BD10

REV.

CHKSUM

E
AA
BA
CA
EA

1780
175B
1615
1692
1707

117
9C00-9FFF

L
8K-4
DISP
BF10

REV.

CHKSUM

E
AA
BA
CA
EA

1B28
1B91
1C05
1CC9
1C67

118	119	120	121
A000-A3FF M 8K-5 DISP AB19	A000-A3FF L 8K-5 DISP AD19	A400-A7FF M 8K-5 DISP AF19	A400-A7FF L 8K-5 DISP AH19
REV.	REV.	REV.	REV.
E AA BA CA CC EA	E AA BA CA CC EA	E AA BA CA CC EA	E AA BA CA CC EA
CHKSUM	CHKSUM	CHKSUM	CHKSUM
1785 17EC 1691 167D 1677 1625	1AD2 1A8C 1BA2 1B2D 1B05 19F7	197E 19CC 18F8 1985 199D 179F	1B85 1BAF 1C92 1C25 1C3C 1BEA

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PAGE

EN
ION

EXCUTIVE FROM CHECKSUM DISCREPANCY

122 A800-ABFF M 8K-5 DISP BA19	123 A800-ABFF L 8K-5 DISP BC19	124 AC00-AFFF M 8K-5 DISP BE19	125 AC00-AFFF L 8K-5 DISP BG19
REV.	REV.	REV.	REV.
E AA BA CA EA	E AA NA CA EA	E AA BA CA EA	E H AA BA CA CC EA
CHKSUM	CHKSUM	CHKSUM	CHKSUM
149C 14A0 14D5 1533 1899	1A68 1A46 1986 1943 1CFF	1683 1707 150B 15CC 17BB	1C95 1C96 1CB5 1B07 1BCD 1BCF 1E12

OM # 100-SP-7895
 DR. RANGE
 /IS
 NK FM
 ARD
 CATION

EXECUTIVE FROM CHEA ASSUM DIS

126
 B000-B3FF
 M
 8K-5
 DISP
 AA28

127
 B000-B3FF
 L
 8K-5
 DISP
 AC28

128
 B400-B7FF
 M
 8K-5
 DISP
 AE28

129
 B400-B7FF
 L
 8K-5
 DISP
 AG28

REV.	CHKSUM	REV.	CHKSUM	REV.	CHKSUM	REV.	CHKSUM
E	1601	E	1C14	E	14B0	E	1966
AA	15ED	AA	1B6A	AA	1479	AA	1941
BA	1429	BA	19B8	BA	13D7	BA	1A23
CA	15T2	CA	19D8	CA	13DB	CA	19C5
CD	1522	CD	19E5	EA	165A	EA	19E3
EA	183C	EA	1B8C				

100-SP-7895
RANGE

EN
ION

EXECUTIVE FROM CHKSUM LISTING

130 B800-BBFF M 8K-5 DISP AJ28	131 B800-BBFF L 8K-5 DISP BB28	132 BC00-BFFF M 8K-5 DISP BD28	133 BC00-BFFF L 8K-5 DISP BF28
REV.	REV.	REV.	REV.
E AA BA CA EA	E AA BA CA EC	E AA BA CA EA	E AA BA CA EA
CHKSUM	CHKSUM	CHKSUM	CHKSUM
140E 13D6 12FF 12F1 OD44	1AE5 1AD7 1981 19CA OE34	1271 128D 1669 1695 19F4	191B 195E 1A49 19F8 1F77

100-SP-7895
RANGE

EN

TION

REV.	CHKSUM	REV.	CHKSUM	REV.	CHKSUM	REV.	CHKSUM
134 C000-C3FF M 8K-6 DISP BJ1	18E0 18EF 1866 190F 1902 1A21	135 C000-C3FF L 8K-6 DISP CB1	1A8D 1A4B 1D1F 1DB7 1DBA 1EOE	136 C400-C7FF M 8K-6 DISP CD1	182A 180F 1C15 1C25 1COD 176B	137 C400-C7FF L 8K-6 DISP CF1	1DEA 1CD6 1D11 1D32 1CAB 1CB1 1CD2 1C11
E AA BD CA CD EA		E AA BF CA CD EA		E AA BA CA CC EA		E AA BA BG CA CC CE EA	

(S)

(C)

(C)

EXCUTIVE FROM CH...

100-SP-7895
RANGE
EN
TION

138 C800-CBFF M 8K-6 DISP CH1	139 C800-CBFF L 8K-6 DISP DA1	140 CC00-CFFF M 8K-6 DISP DCL	141 CC00-CBFF L 8K-6 DISP DE1
REV.	REV.	REV.	REV.
CHKSUM	CHKSUM	CHKSUM	CHKSUM
E AA BA CA CC EA	E AA BB CA CC EA	E AA BA CA EA	E AA BA CA EA
1AFB 1B5D 1BAE 1CAB 1C6A 17FD	1FF7 1E4F 1DAF 1DAB 1DB2 1D91	17BD 177E 171C 1773 1699	1A69 1956 1AEA 1A9E 1C1E

100-SP-7895
 RANGE
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 RD
 VATION

142 D000-D3FF M 8K-6 DISP BH10	143 D000-D3FF L 8K-6 DISP CA10	144 D400-D3FF M 8K-6 DISP CC10	145 D400-D7FF L 8K-6 DISP CE10
REV. E AA BA CA EA	REV. E AA BA CA EA	REV. E AA BD CA EA	REV. E AA BD CA EA
CHKSUM 180C 1811 185A 18B8 107A	CHKSUM 1AFO 1AD1 1BB6 1BA9 11D3	CHKSUM 156D 152F 177E 15D2 1648	CHKSUM 1CAE 1BD1 1BF4 1B62 1BFB

EXECUTIVE FROM CHECKSUM LISTING

REV.	CHKSUM	REV.	CHKSUM	REV.	CHKSUM	REV.	CHKSUM
146	D800-DBFF	147	D800-DBFF	148	DC00-DFFF	149	DC00-DFFF
M	8K-6	L	8K-6	M	8K-6	L	8K-6
DISP	DISP	DISP	DISP	DISP	DISP	DISP	DISP
CG10	CG10	CJ10	CJ10	DB10	DB10	DD10	DD10
E	0BF5	E	102E	E	16DA	E	1925
AA	OC1B	AA	1028	M	16CC	F	1923
BA	OC46	BA	11B6	N	16C0	M	1940
CA	OCF1	CA	126D	AA	1694	N	194E
EA	1A46	EA	1C5A	AF	1680	AA	19A1
				AG	1574	AF	19B8
				BA	1758	AG	19C6
				CA	1636	BD	1A71
				CG	162C	CA	1969
				EB	189B	CG	1970
						EB	1870

100-SP-7895
RANGE

EN
TION

EX-100-SP-7895

REV.	CHKSUM	REV.	CHKSUM	REV.	CHKSUM	REV.	CHKSUM
150 E000-E3FF L 8K-7 DISP BJ19	18CA 18FE 1865 1933 13FC	151 E000-E3FF L 8K-7 DISP CB19	1CF7 1D00 1D01 1CE4 186F	152 E400-E7FF M 8K-7 DISP CD19	196B 1942 19CD 19B4 1772	153 E400-E7FF L 8K-7 DISP CF19	1CD4 1D78 1E02 1DCB 17EE
E AA BA CA EA		E AA BA CA EA		E AA BA CA EC		E AA BA CA EC	

REV.	CHKSUM	REV.	CHKSUM	REV.	CHKSUM	REV.	CHKSUM				
154 E800-EBFF M 8K-7 DISP CH19	1892 1892 188F 1889 1888 1885 175B 16CE 1BF4 1BFB	E K L AA AC AE BA CA EB ED	155 E800-EBFF L 8K-7 DISP DA19	1E28 1E18 1E0E 1E06 1DF9 1DEF 1BB2 1BE3 1D92 1D98	E K L AA AC AE BA CA EB ED	156 EC00-EFFF M 8K-7 DISP DC19	18D6 18AA 1A7F 18D6 1A22	E AA BD CA CA EA	157 EC00-EFFF L 8K-7 DISP DE19	1CAF 1BE4 1D2B 1C5C 1A92	E AA BD CA CA EA

EXECUTIVE PROM CHKSUM LISTINGS

100-SP-7895

PANGE

EN

CTION

158
F000-F3FF
M
8K-7
DISP
BH28

REV. CHKSUM

E
AA
BA
CA
EB

1A6A
1A53
1A97
1ABC
17CC

159
F000-F3FF
L
8K-7
DISP
CA28

REV.

E
AA
BA
CA
EB

1AE6
1BBC
1D1E
1C18
18AA

CHKSUM

160
F400-F7FF
M
8K-7
DISP
CC28

REV.

E
H
AA
BA
CA
CC
CD
EB

CHKSUM

1F81
1F81
1E53
1OF6
1E83
14D8
162C
1870

161
F400-F7FF
L
8K-7
DISP.
CE28

REV.

E
H
AA
BA
CA
CC
CD
EB

CHKSUM

21D8
21DE
213E
1349
22C7
1976
1AF2
1964

4 # 100-SP-7895

2. RANGE

3. S

4. FH

5. RD

6. VTION

REV.	CHKSUM	REV.	CHKSUM	REV.	CHKSUM	REV.	CHKSUM
B C AA	162 F800-FBFF M 8K-7 DISP CG28	B C AA	163 F800-FBFF L 8K-7 DISP CJ28	B C AA	164 FC00-FFFF M 8K-7 DISP DB28	B C AA	165 FC00-FFFF L 8K-7 DISP DB28
	1B09 1B09 1B09		205F 2073 2073		2E6C 234E 234E		3122 287E 287E

100-SP-1895

RANGE

S

EN

D

TION

REV.	CHKSUM	REV.	CHKSUM	REV.	CHKSUM	REV.	CHKSUM
229 4000-43FF M 8K-2 FFT/AVG BA1	1331 1313 12F8 1760 184E 154F	230 4000-43FF L 8K-2 FFT/AVG BC1	1A6C 1A6D 1A6F 1A70 1A71 1A72 1BC1 1B02 1B03 1B04 1B06 1C82 1C83 1C84 1C86 1BEF 1BEE 1BE1 1BE2 1BE3 1A38 1A39	231 4400-47FF M 8K-2 FFT/AVG BE1	163B 1647 1175 117D 113D	232 4400-47FF L 8K-2 FFT/AVG BG1	1B56 1B9B 1A0E 1A2B 1A2C
E H AA BA CA EA		E H K L M N AA AC AE AF AG BD BE BF BH CA CC CE CF CG EC ED		E AA BA CA EA		E AA BA CA EA	

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100-SP-7895
 RANGE
 EN
 D
 TION

233 4800-4BFF M 8K-2 FFT/AVG BG1	234 4800-4BFF L 8K-2 FFT/AVG BJ1	235 4C00-4FFF M 8K-2 FFT/AVG CBL	236 4C00-4FFF L 8K-2 FFT/AVG CD1
REV. E AA BA CA CC EA	REV. E H AA BA CA CC EA	REV. E AA BA CA CC EA	REV. E AA BA CA CC EA
CHKSUM 172E 1736 18AC 1921 1925 132A	CHKSUM 1A36 1A34 1A19 1D06 1CEFF 1CFA 1A17	CHKSUM 1673 16B4 153B 15F6 1608 1431	CHKSUM 1C1C 1BF5 1B2C 1ADC 1AE3 1AOB

100-SP-7095
RANGE

FM

ION

237
5000-53FF
M.
8K-2
FFT/AVG
AJ10

REV.	CHKSUM
E	19BA
H	19AF
AA	1973
BD	1A70
CA	1ABC
CC	1ABF
CD	1AD7
EA	1951

238
5000-53FF
L
8K-2
FFT/AVG
BB10

REV.	CHKSUM
E	1AD0
H	1AD6
AA	1ACD
BD	1EB2
CA	1E61
CC	1E63
CD	1E4F
EA	1EAO

239
5400-57FF
M
8K-2
FFT/AVG
BD10

REV.	CHKSUM
E	1672
AA	1760
BA	188C
CA	1927
CB	1927
EA	107F

240
5400-57FF
L
8K-2
FFT/AVG
BF10

REV.	CHKSUM
E	1R00
AA	1B6A
BA	1E1E
CA	1E12
CB	1E12
EA	1699

100-SP-7695

RANGE

EH

ION

241
5800-5BFF
M
8K-2
FFT/AVG
BH10

242
5800-5BFF
L
8K-2
FFT/AVG
CA10

243
5C00-5FFF
M
8K-2
FFT/AVG
CC10

244
5C00-5FFF
L
8K-2
FFT/AVG
CE10

REV. CHKSUM

E
AA
BA
CA
EA
14B7
1439
141B
149A
N/A

REV. CHKSUM

E
AA
BA
CA
EA
17AA
178E
1A75
1A5A
N/A

REV. CHKSUM

E H K M N
AA AF AG BE BH CA CC CF CG EA
237D
228A
21A7
2169
2102
2465
2427
23C0
16E0
16F7
2000
1FEF
1FBC
1FOD
N/A

REV. CHKSUM

E H K M N
AA AF AG BE BH CA CC CF CG EA
26E9
2615
254B
250C
24B7
2752
272B
26DD
17C1
1800
21B0
2117
210B
208A
N/A

245
6400-67FF
M
8K-3
FFT/AVG
AH19

246
6400-67FF
L
8K-3
FFT/AVG
BA19

247
6800-6BFF
M
8K-3
FFT/AVG
BC19

248
6800-6BFF
L
8K-3
FFT/AVG
BE19

REV. CHKSUM
E 179A
AA 1821
BA N/A
CA N/A
EA 1B09

REV. CHKSUM
E 1C44
AA 1BA2
BA N/A
CA N/A
EA 1E98

REV. CHKSUM
F 1714
AA 1713
BD 14A0
BE 14FB
BF 1549
CA 23B3
CD 2174
CG 216E
EA 117F

REV. CHKSUM
E 1AA5
AA 19EF
BD 1714
BE 175B
BF 17C5
CA 2850
CD 2633
CG 2641
EA 1478

249 6C00-6FFF M 8K-3 FFT/AVG BG19	250 6C00-6FFF L 8K-3 FFT/AVG BJ19	251 7000-73FF M 8K-3 FFT/AVG CB19	252 7000-73FF L 8K-3 FFT/AVG CD19
REV.	REV.	REV.	REV.
CHKSUM	CHKSUM	CHKSUM	CHKSUM
E H L AA AE BA CA EB	2448 2451 23AF 241A 2379 N/A N/A 13F4	25B5 25B8 254D 260B 259E N/A N/A 12B3	2002 1F1F 1EC9 201D 1FCE 1EDA 1EE6 N/A N/A 1085
		E H K AA AC AD AE BA CA EA	F H K AA AC AD AE BA CA EA

EXECUTIVE PROM CHECKSUM LISTING

100-SP-7895
 RANGE
 FN
 DIVISION

356
 4000-43FF
 T.
 8K±2
 FFT/AVG
 BAI

CHKSUM

REV.

CHKSUM

REV.

CHKSUM

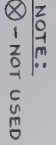
REV.

CHKSUM

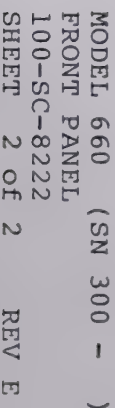
REV.

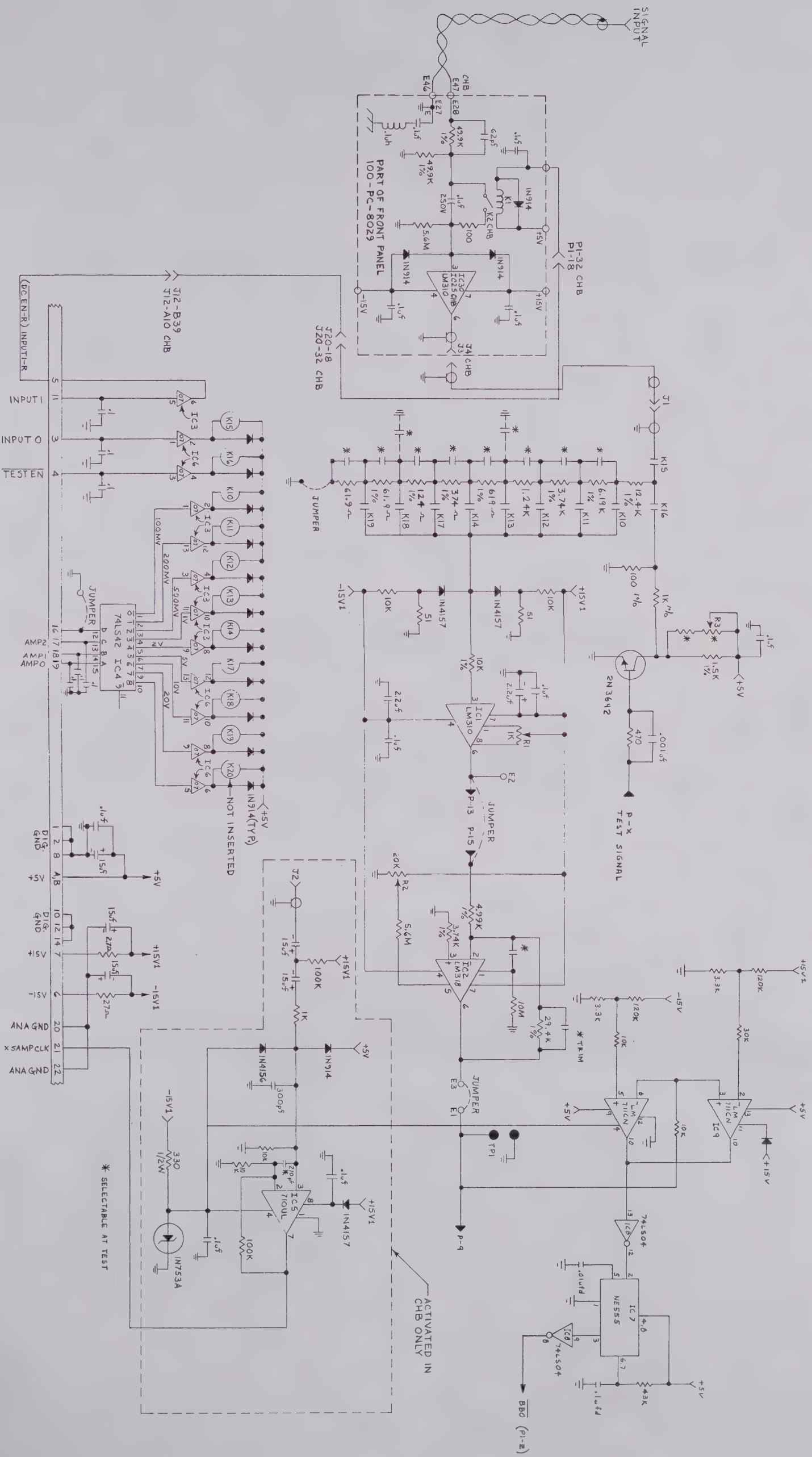
BD
 BE
 BF
 BH
 CC
 CE
 CF
 CG
 EC
 ED

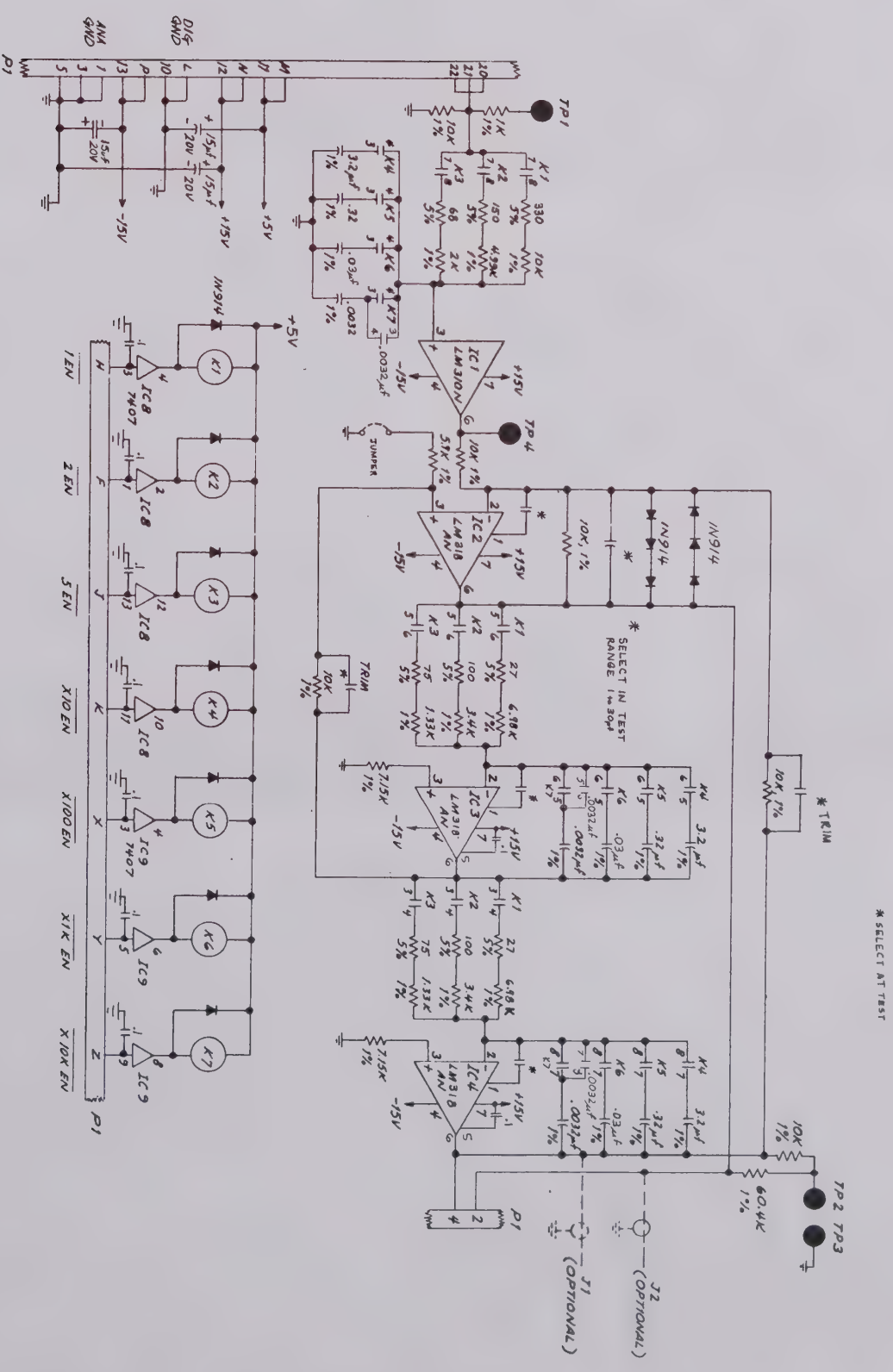
1C84
 1C85
 1C86
 1C88
 1BFO
 1BE3
 1BE4
 1BE5
 1A3A
 1A3B

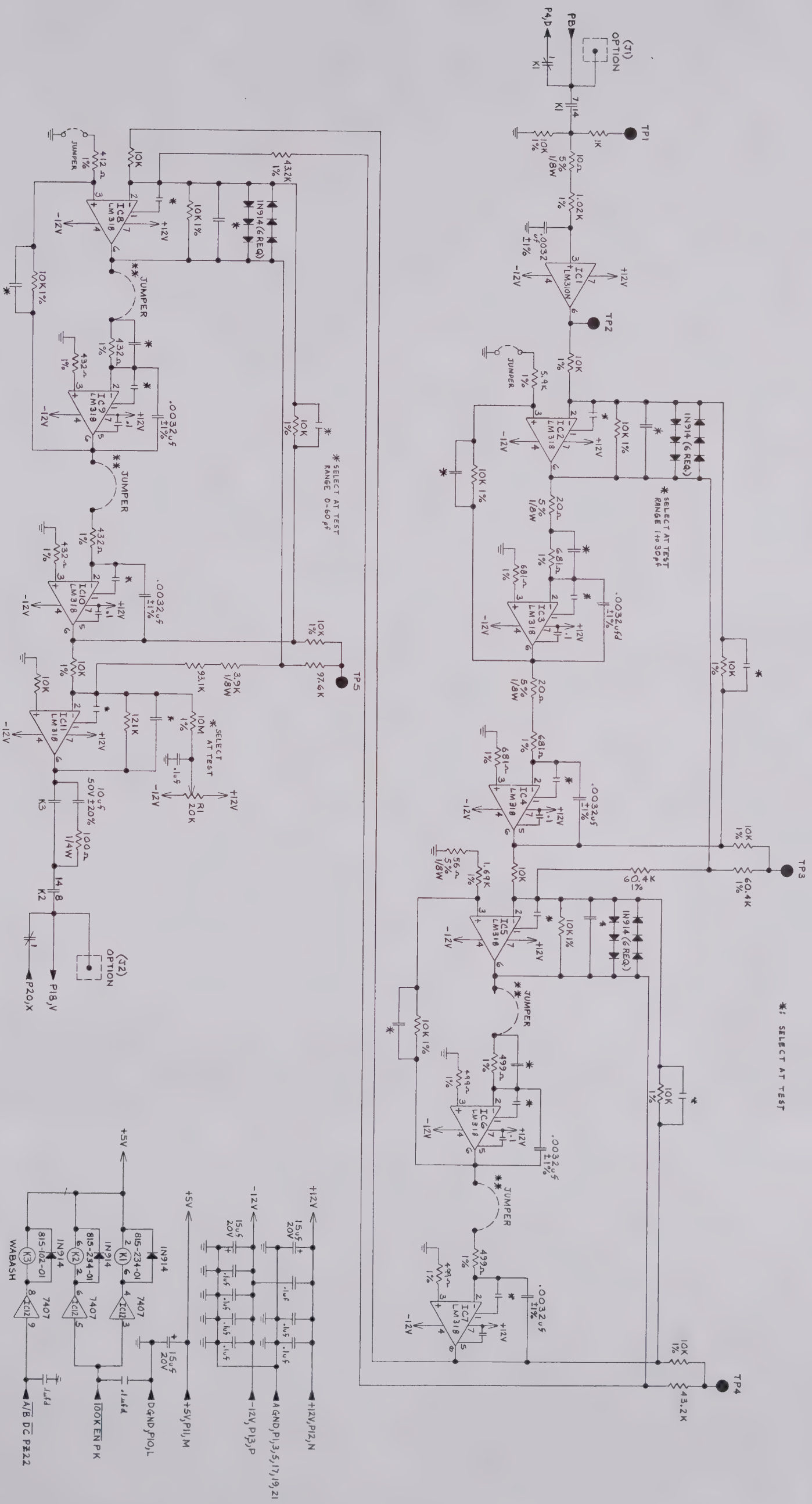


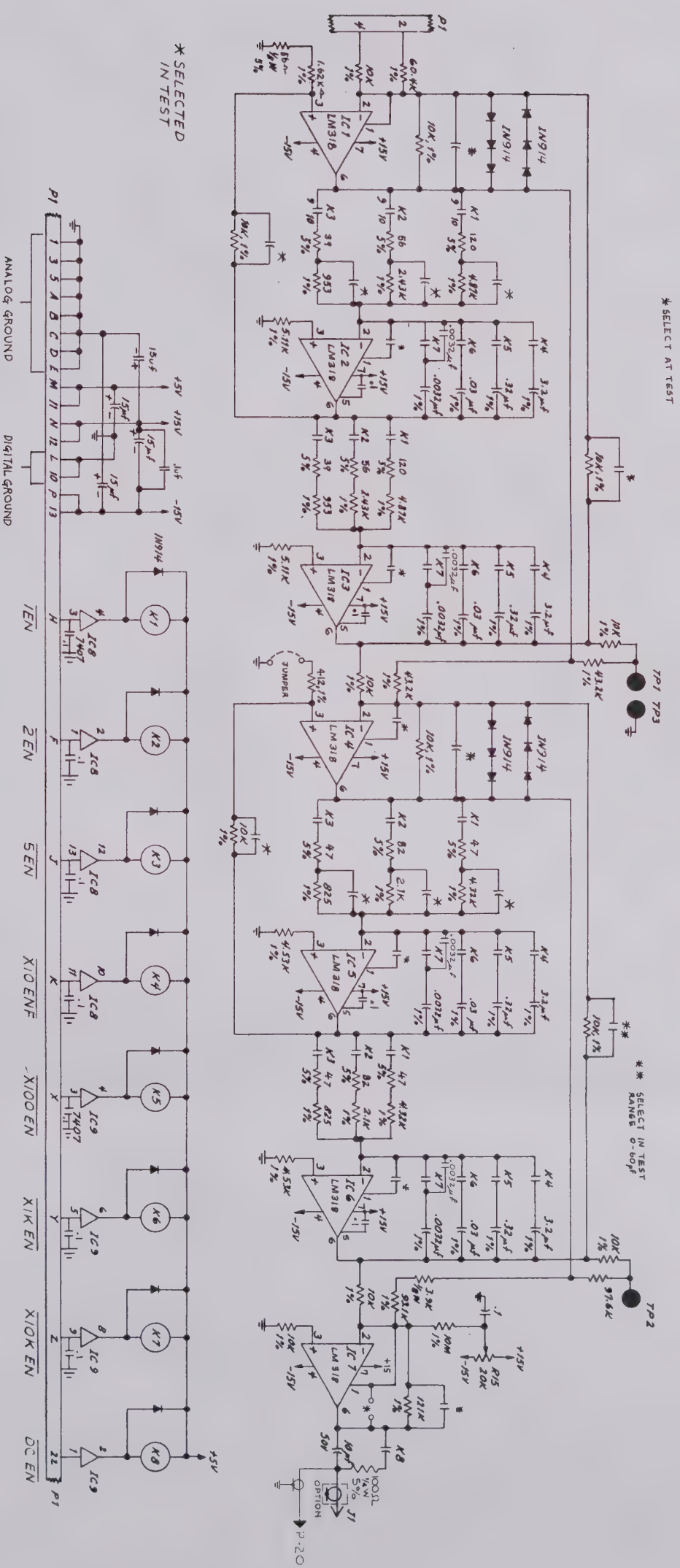
REV E
2-80





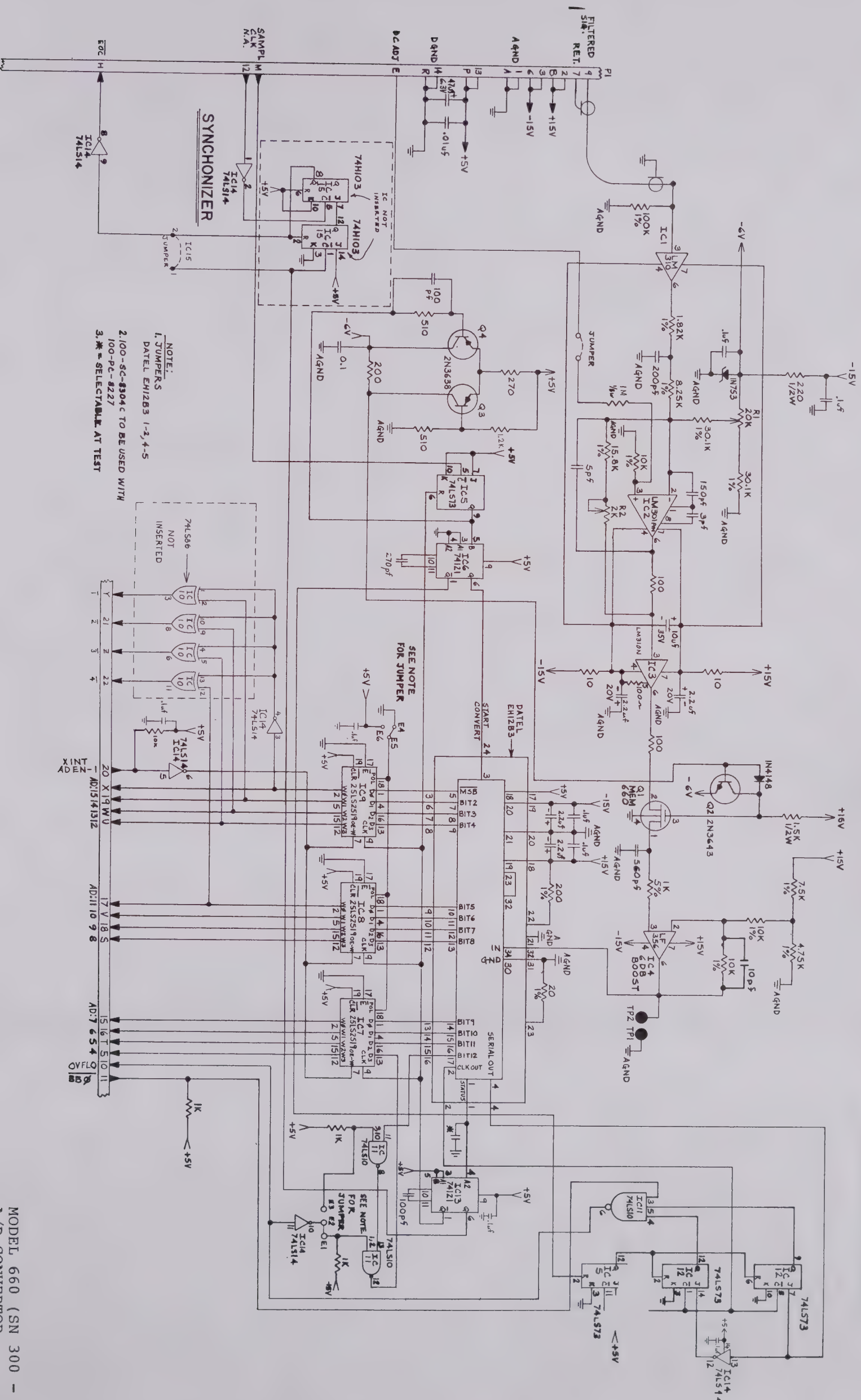






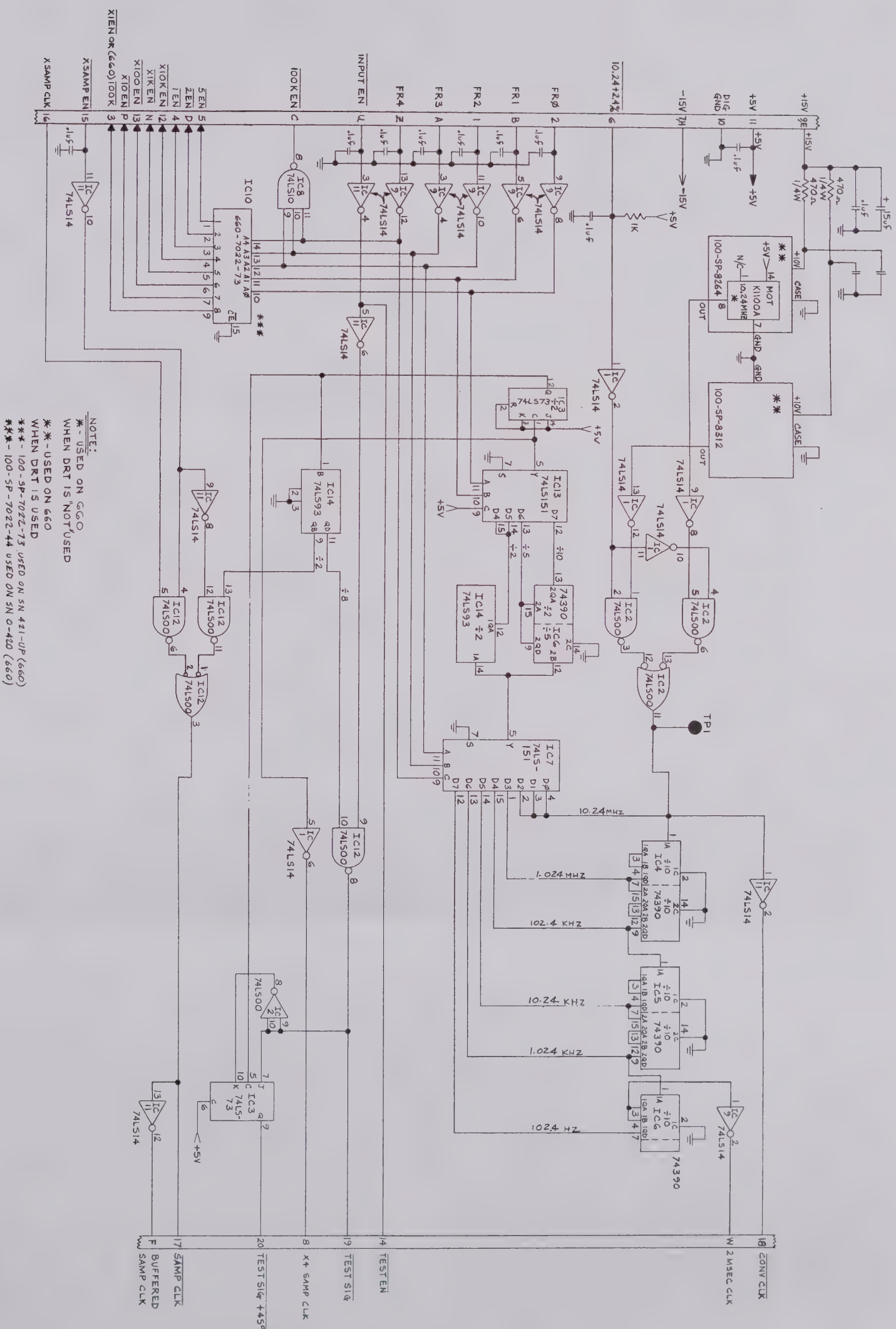
MODEL 660 (SN 300 -)
 FILTER NUMBER 2
 100-SC-8614
 SHEET 1 of 1 REV E

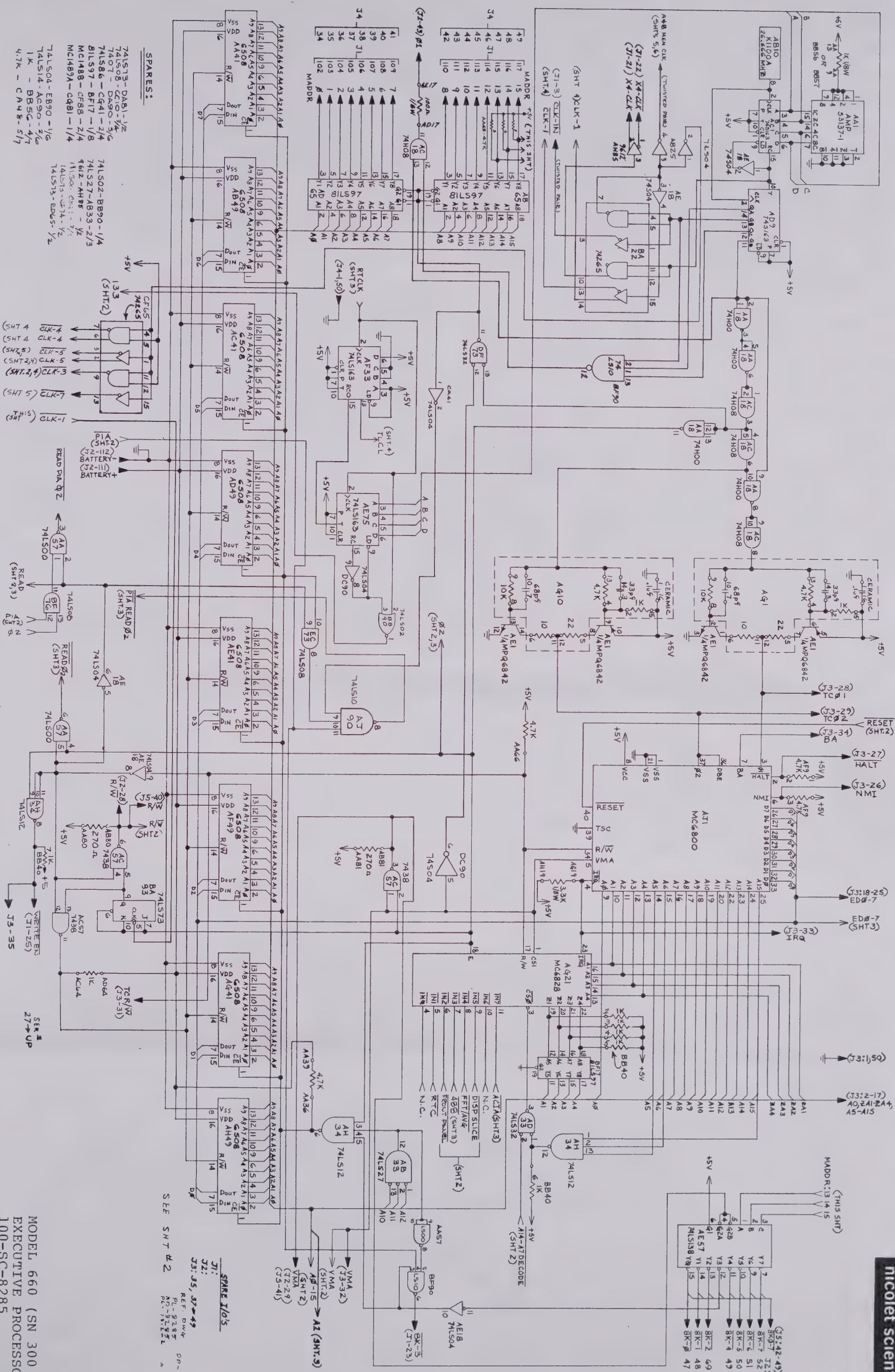
OFFSET AMPLIFIER

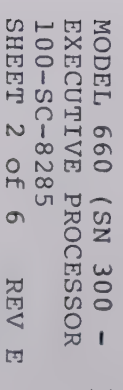


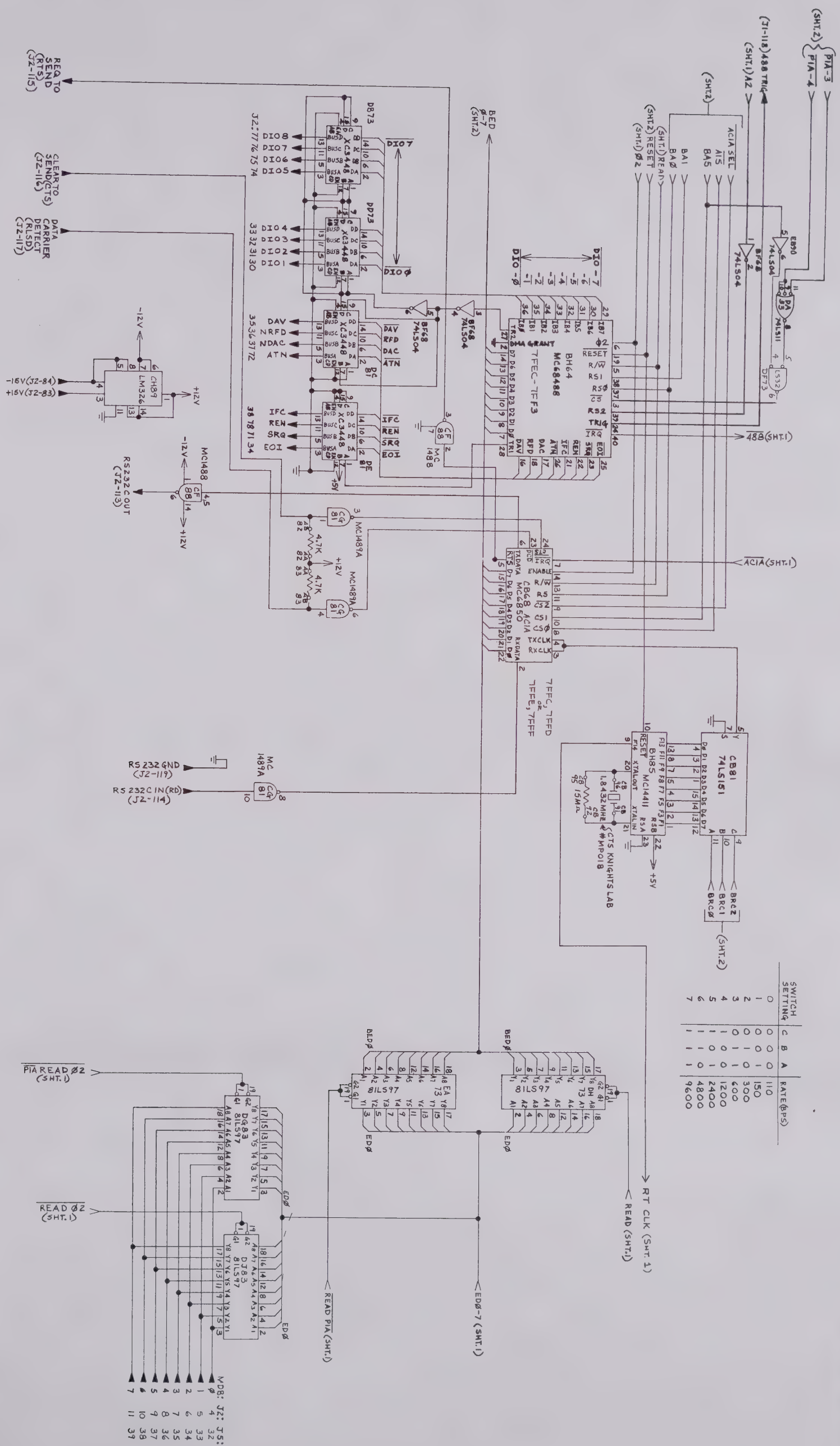
SAMPLE & HOLD

OVERLOAD DETECTION

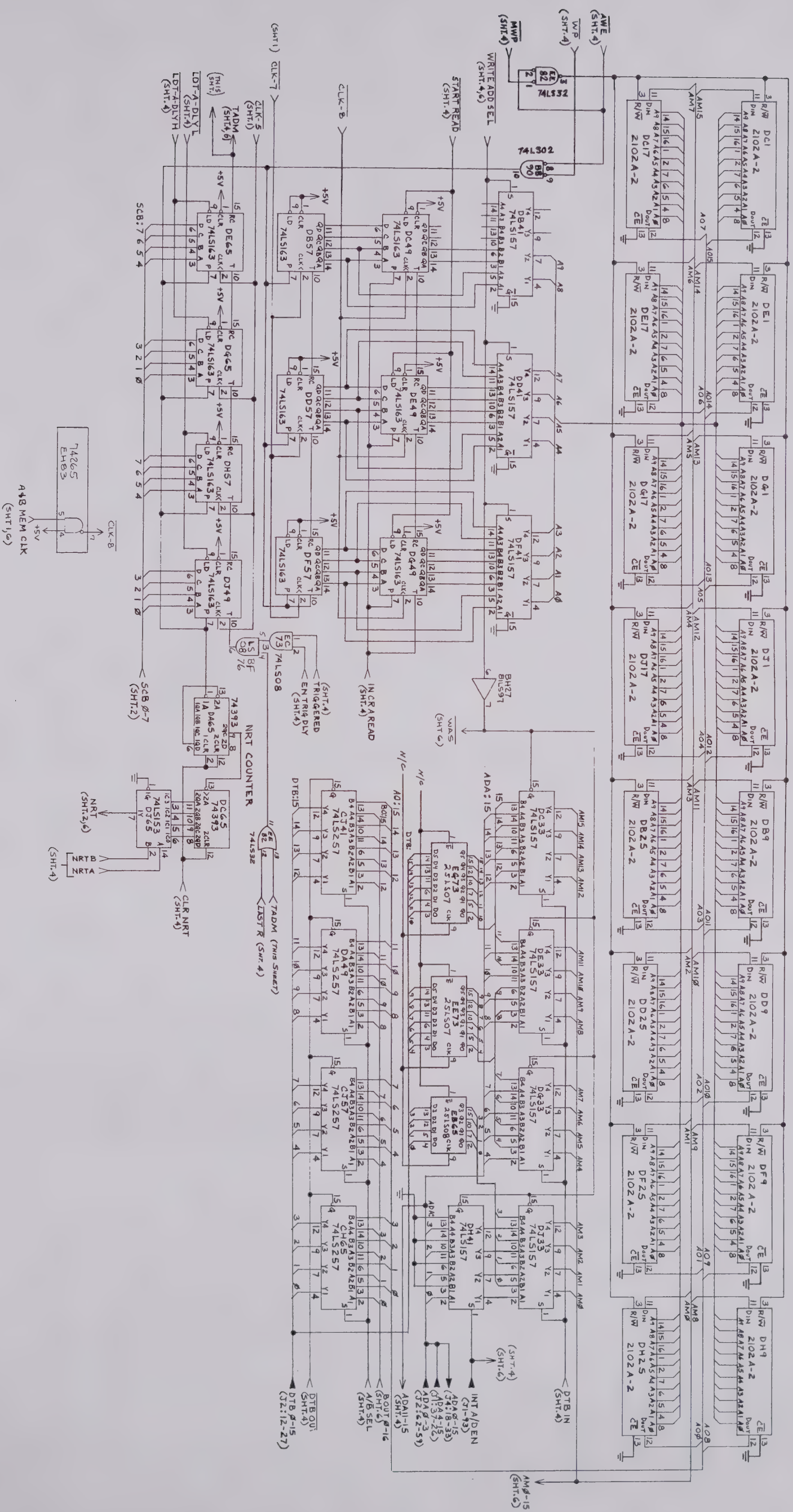


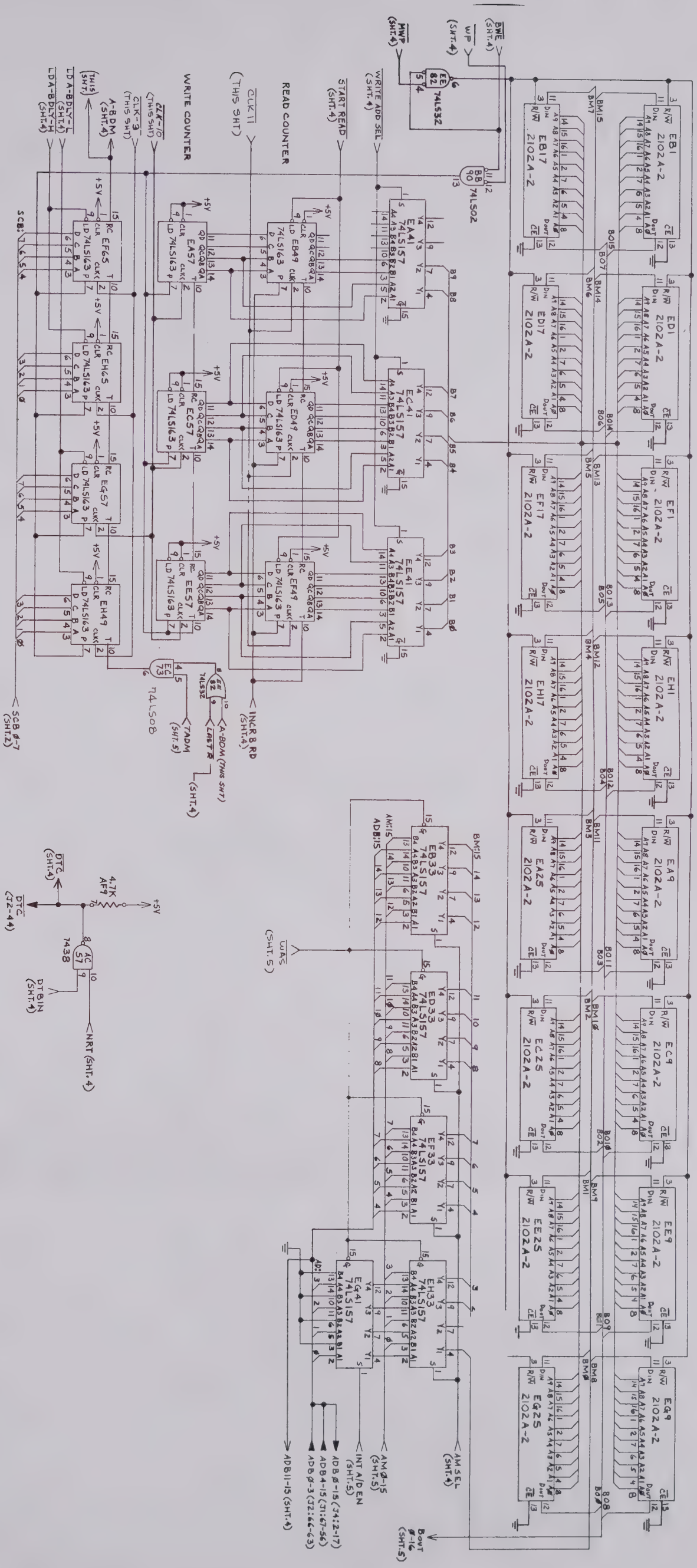


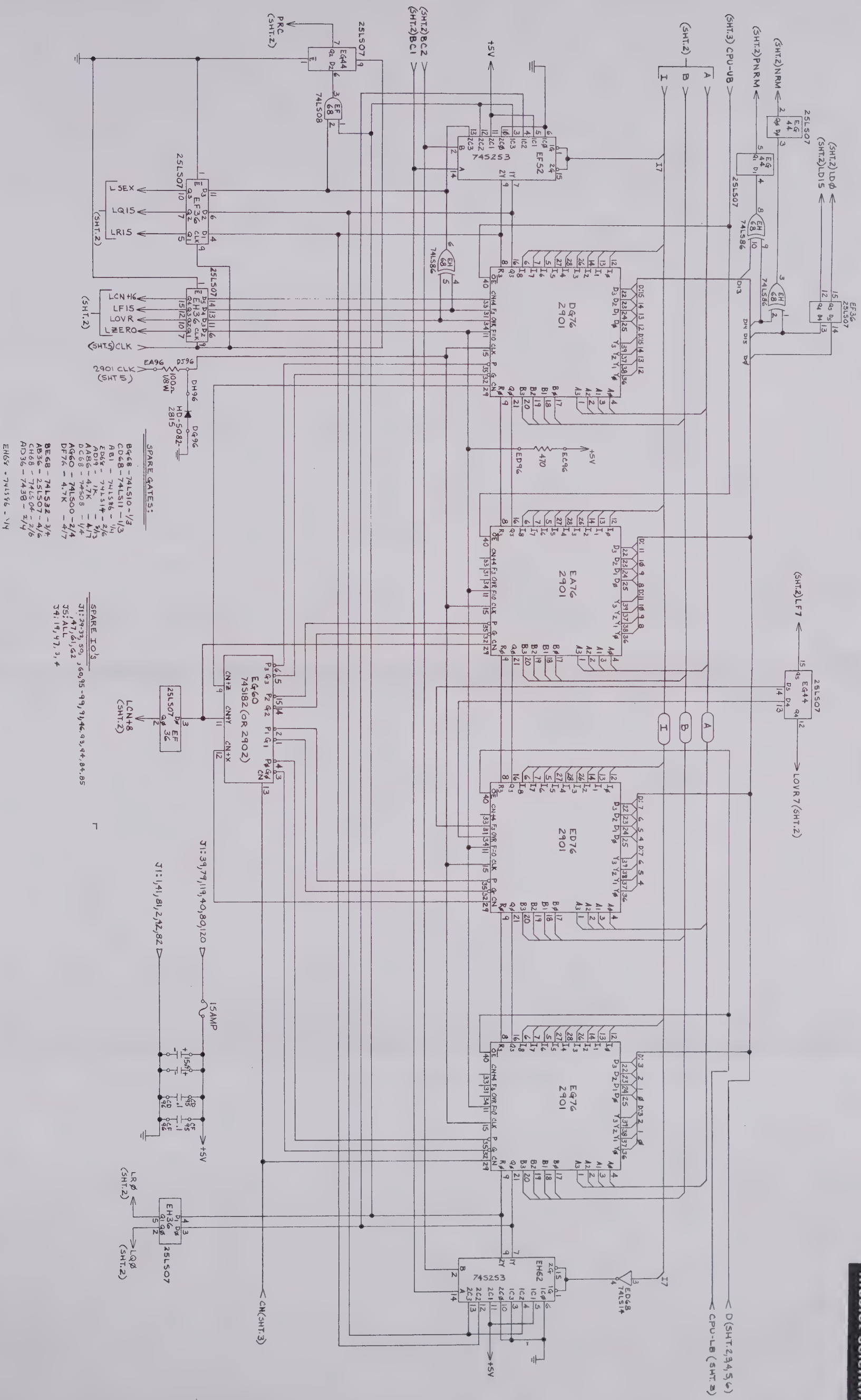


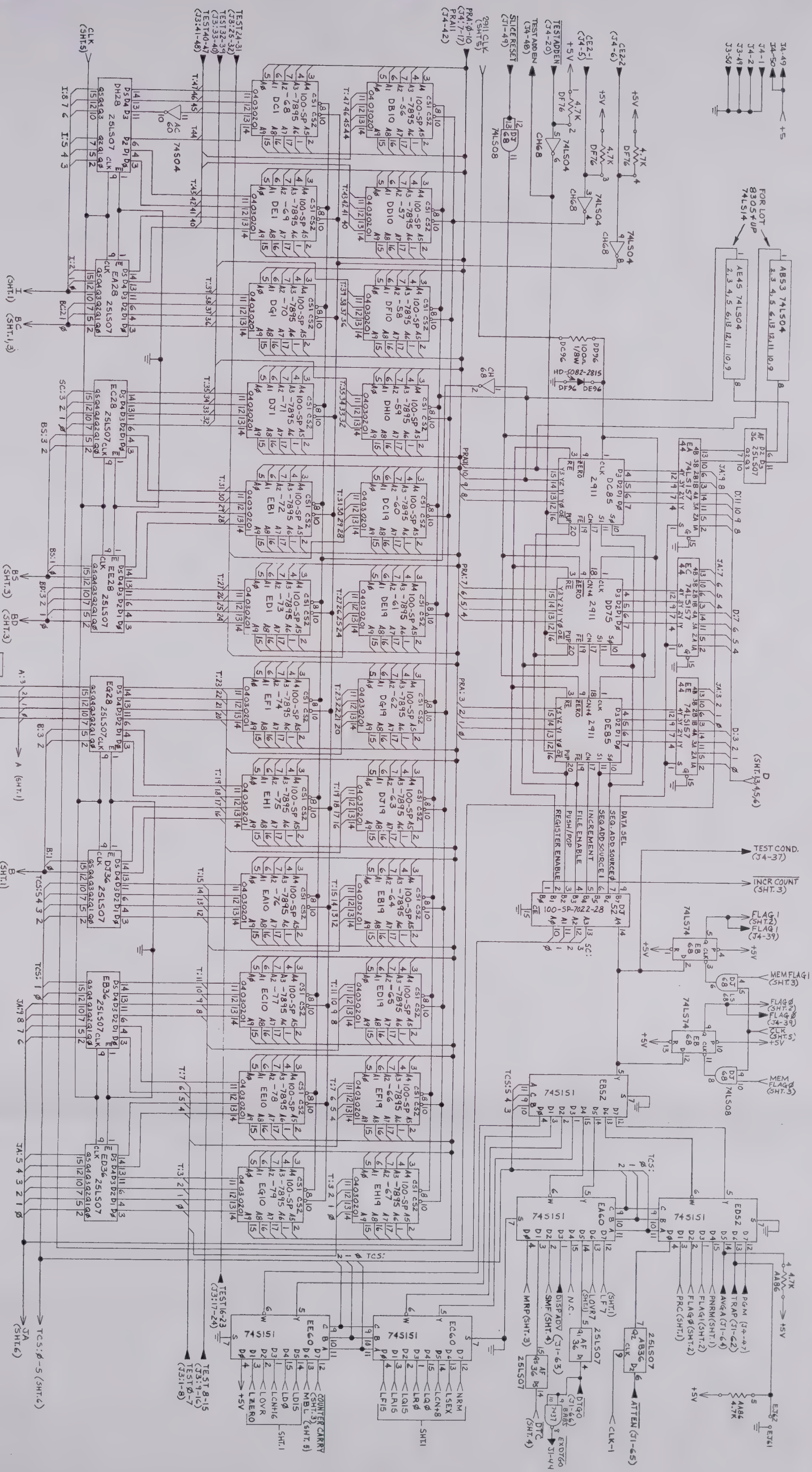


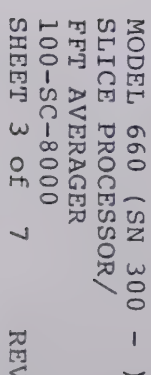
SWITCH SETTING	C B A				RATE (PPS)
	0	1	2	3	
1	0	0	0	0	110
2	0	0	1	0	150
3	0	1	0	0	300
4	0	1	1	0	600
5	1	0	0	0	1200
6	1	0	1	0	2400
7	1	1	0	0	4800
	1	1	1	0	9600

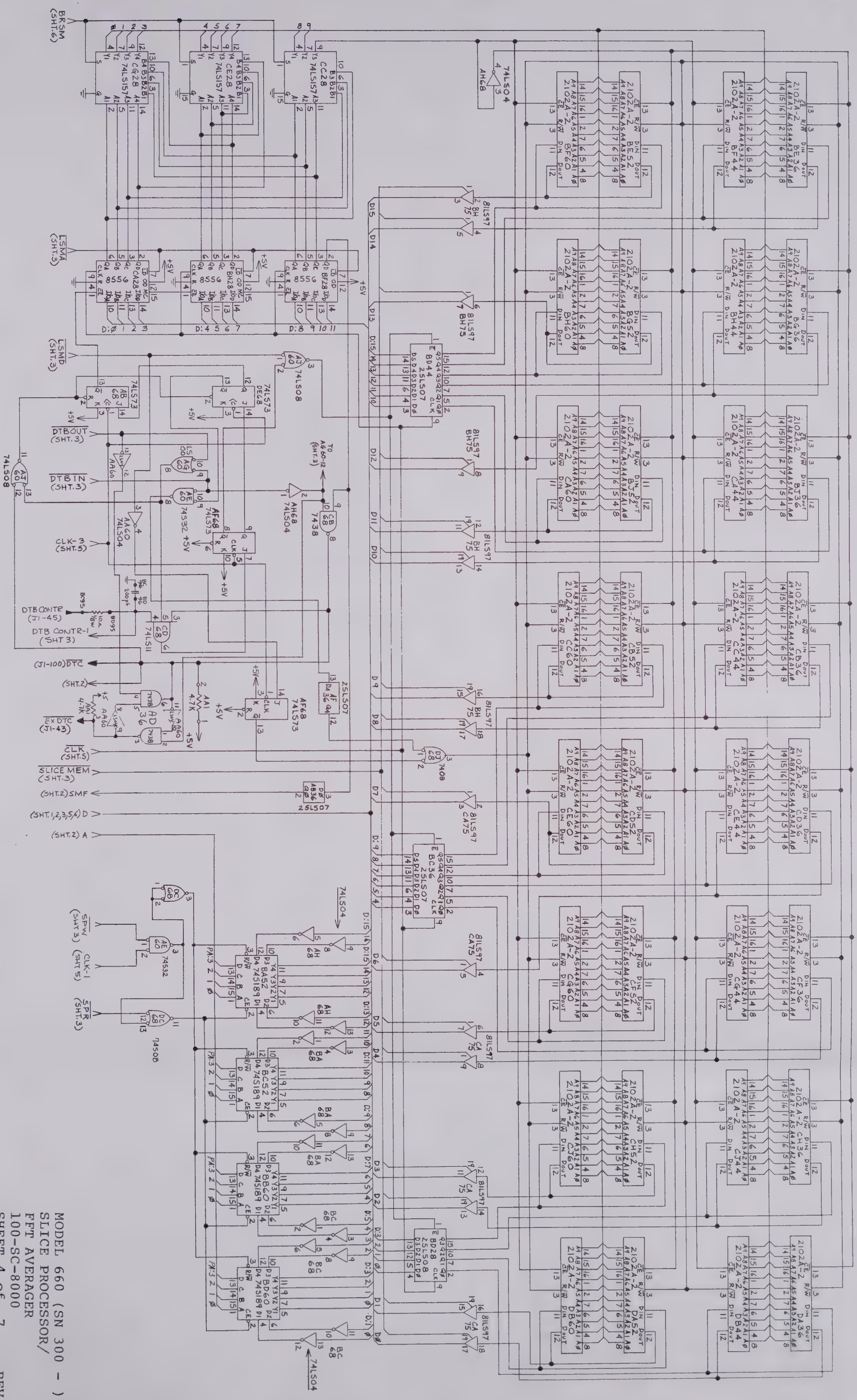


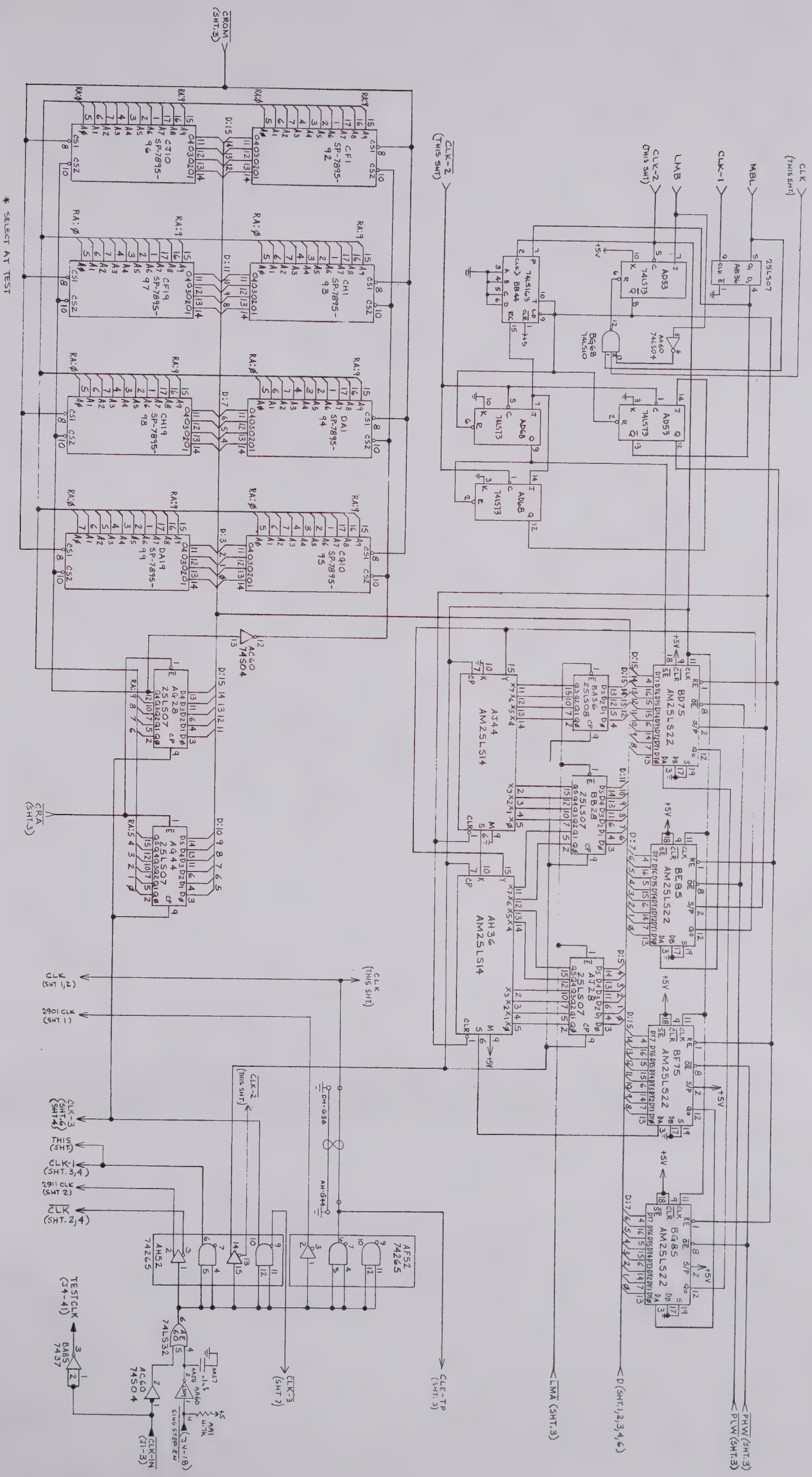


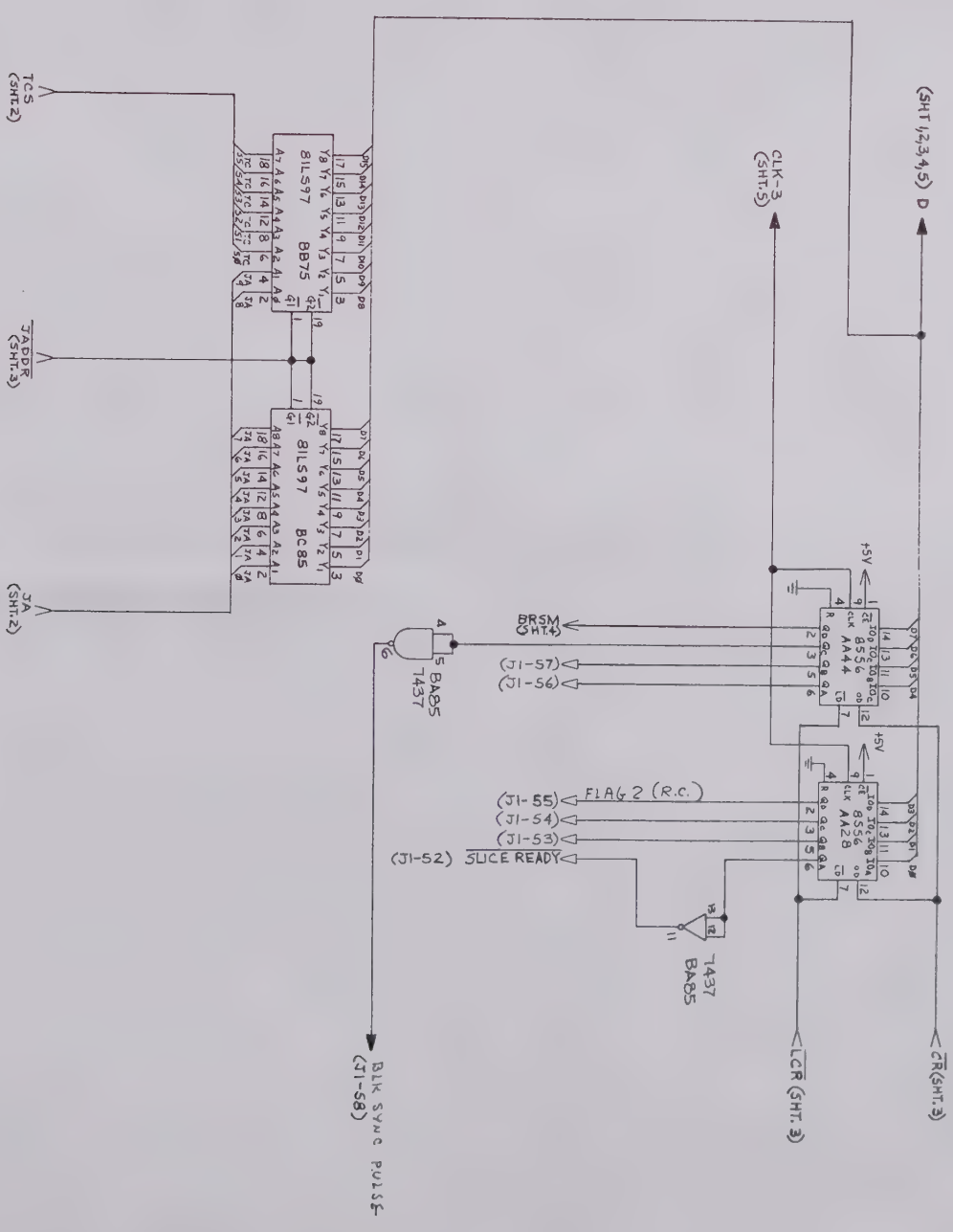
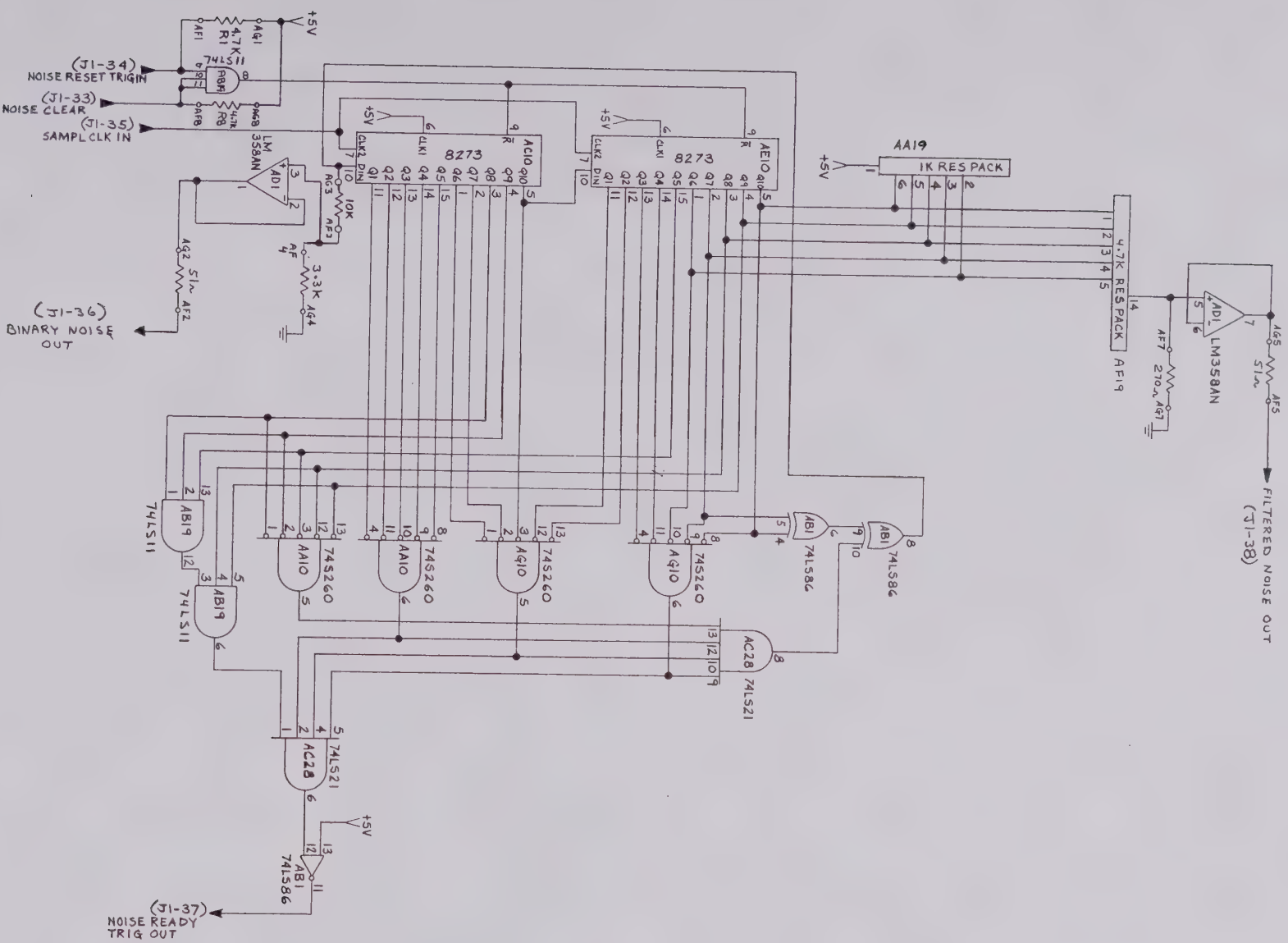


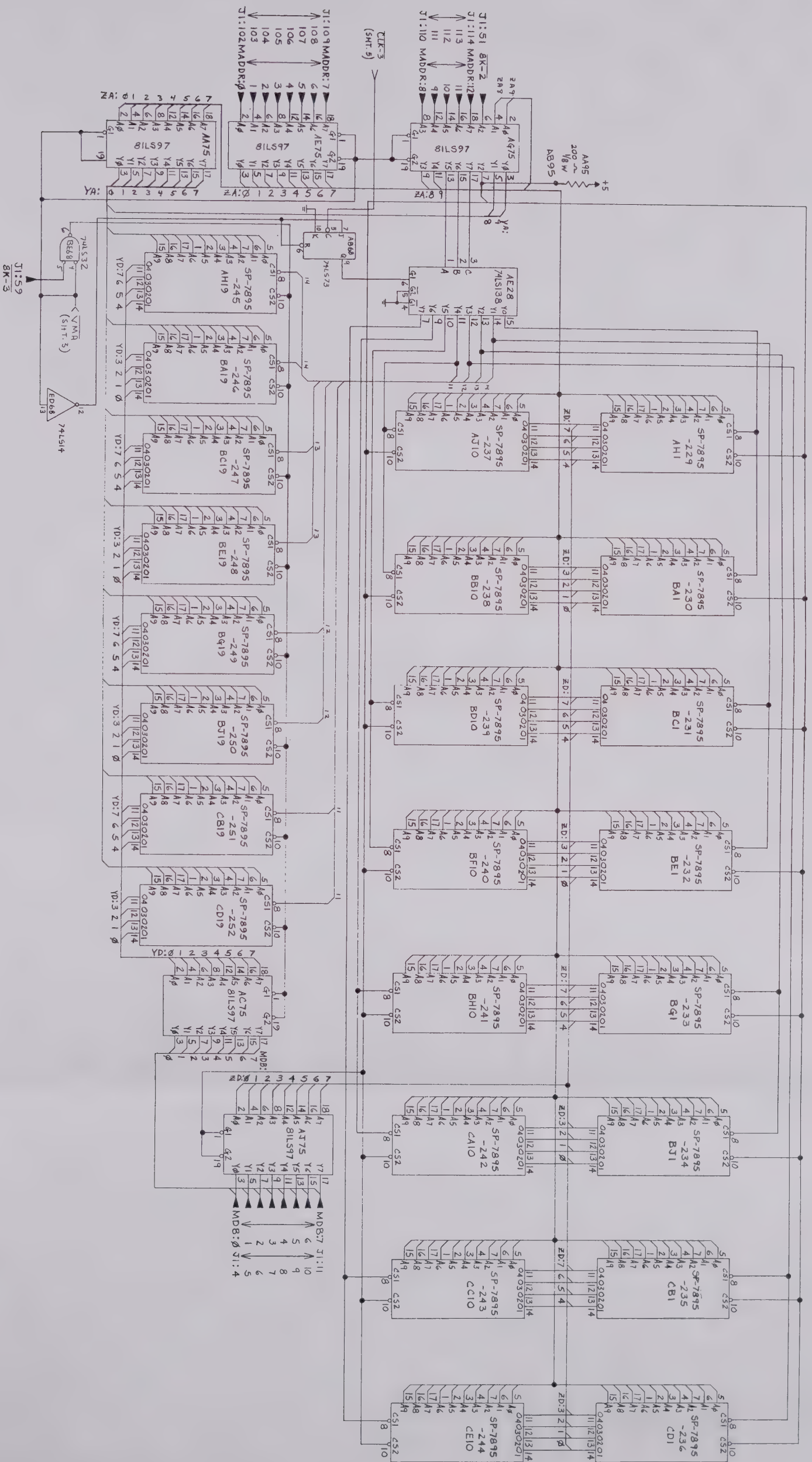


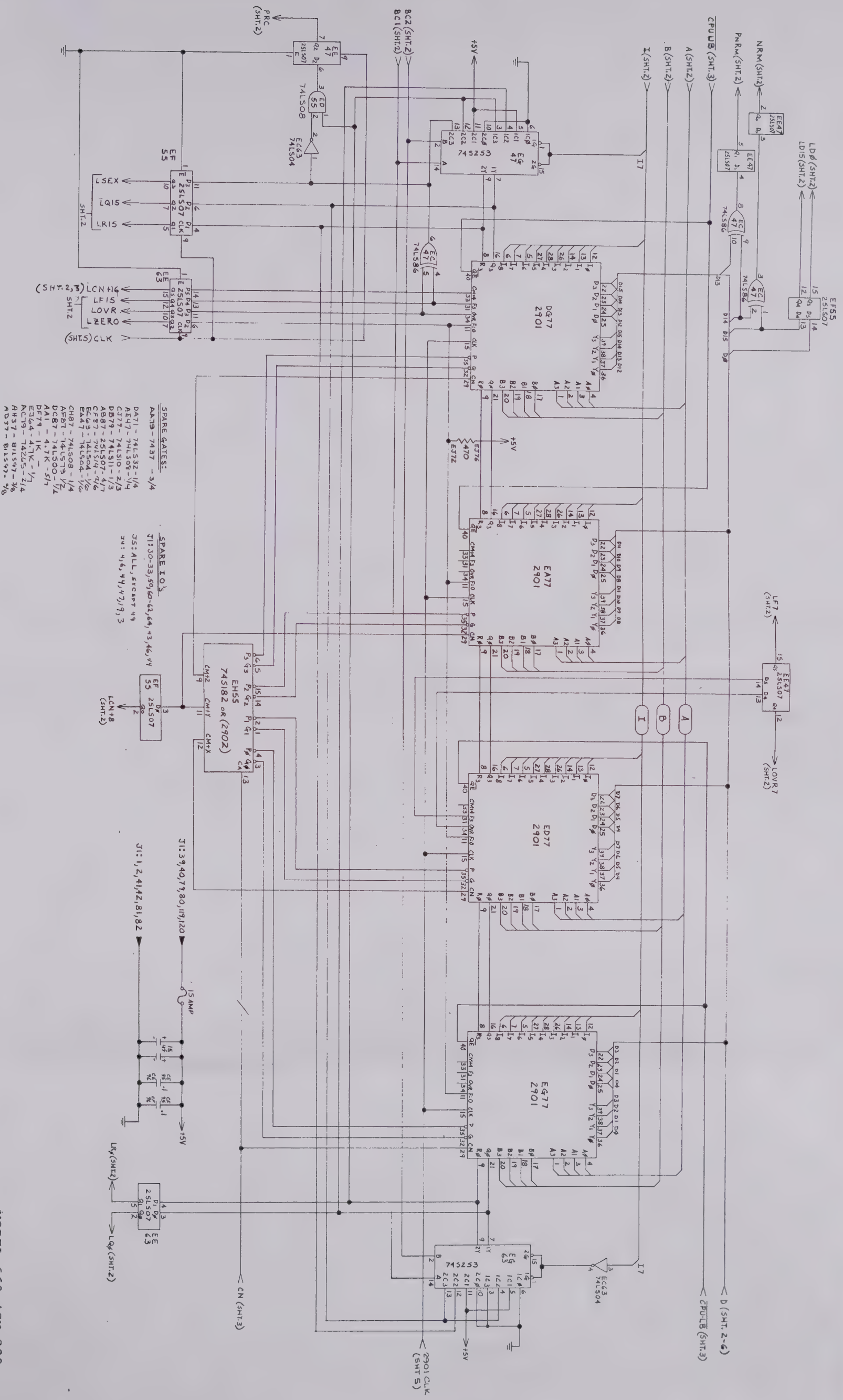


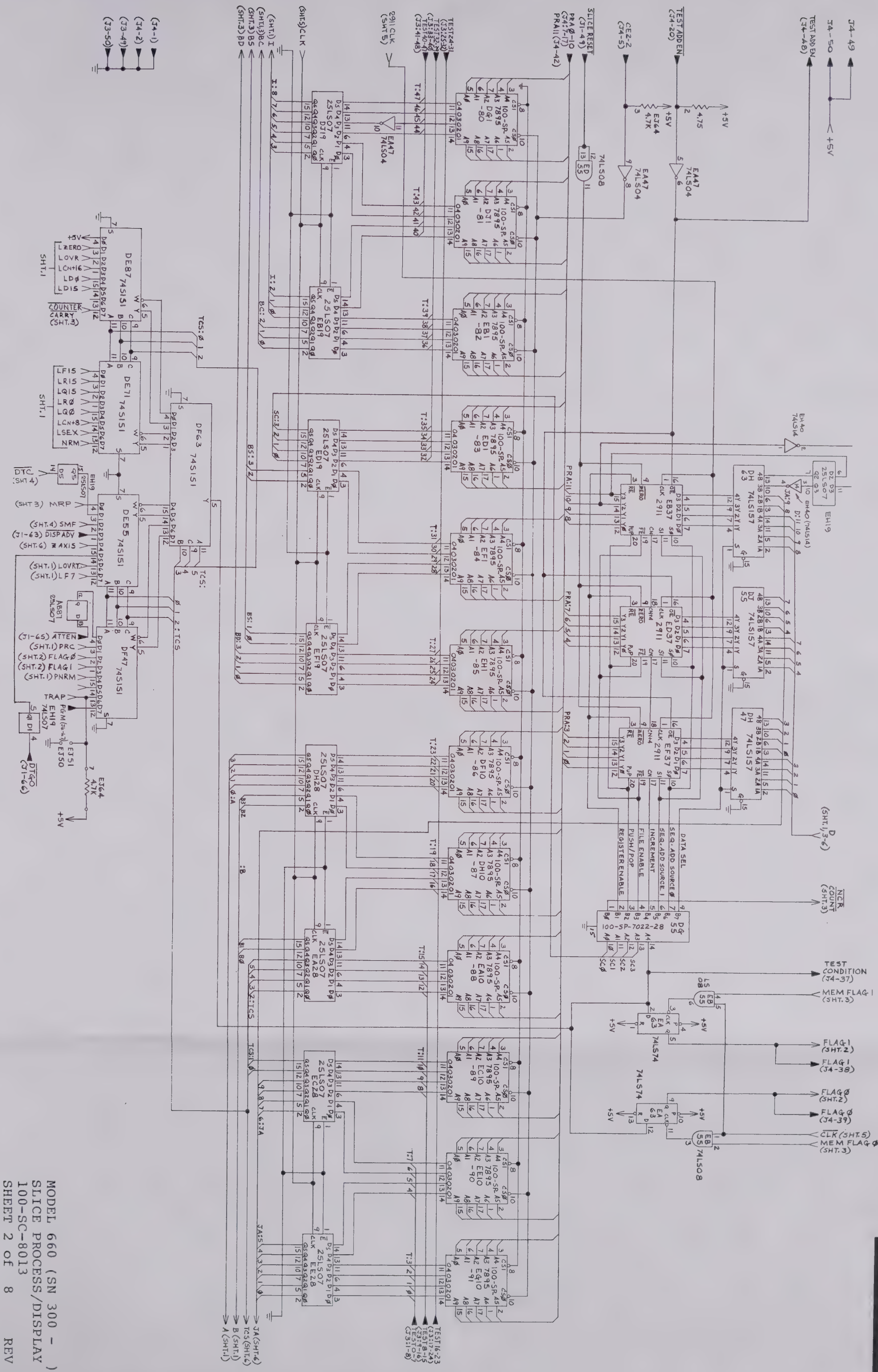


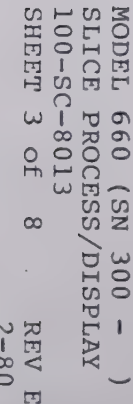


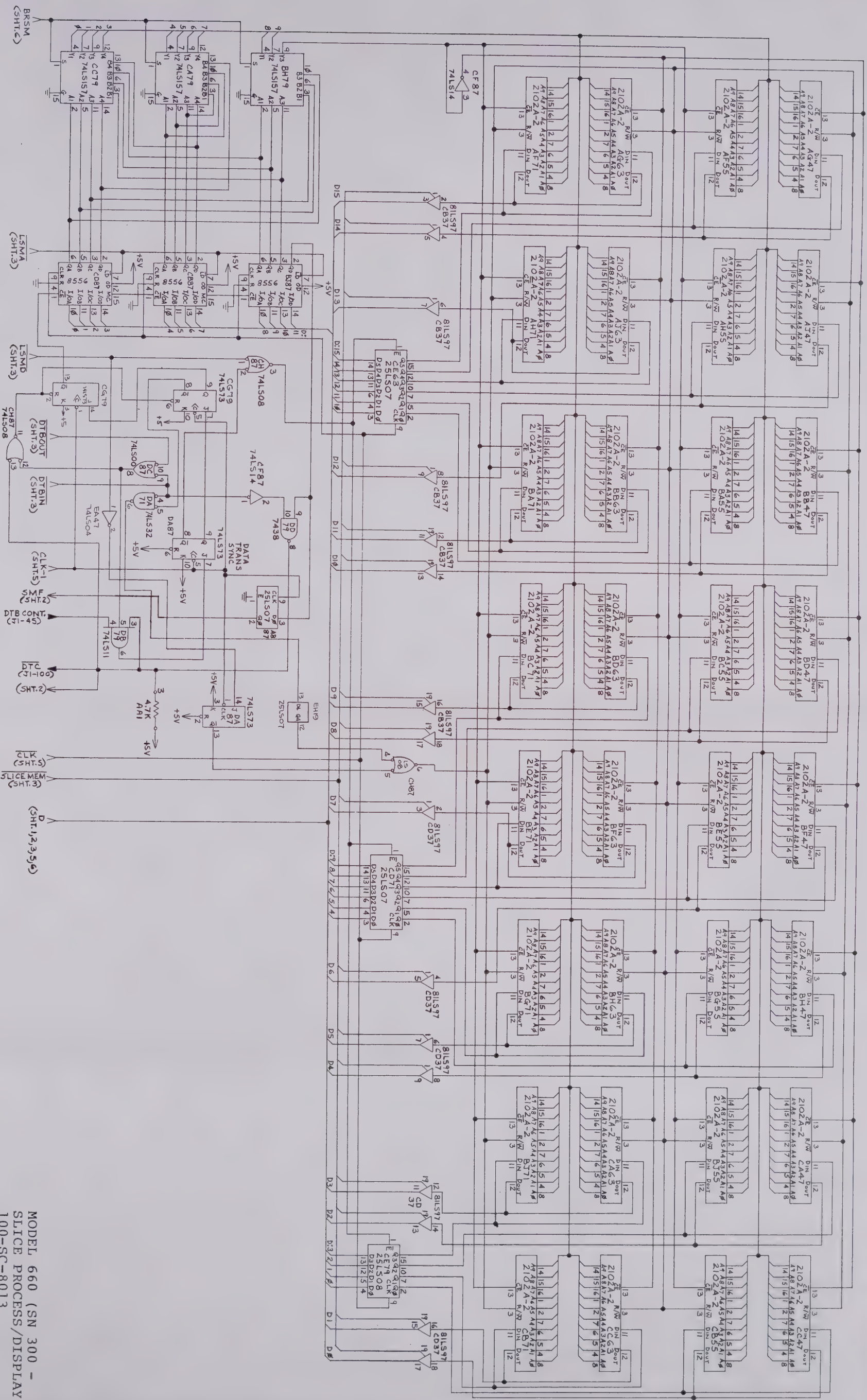


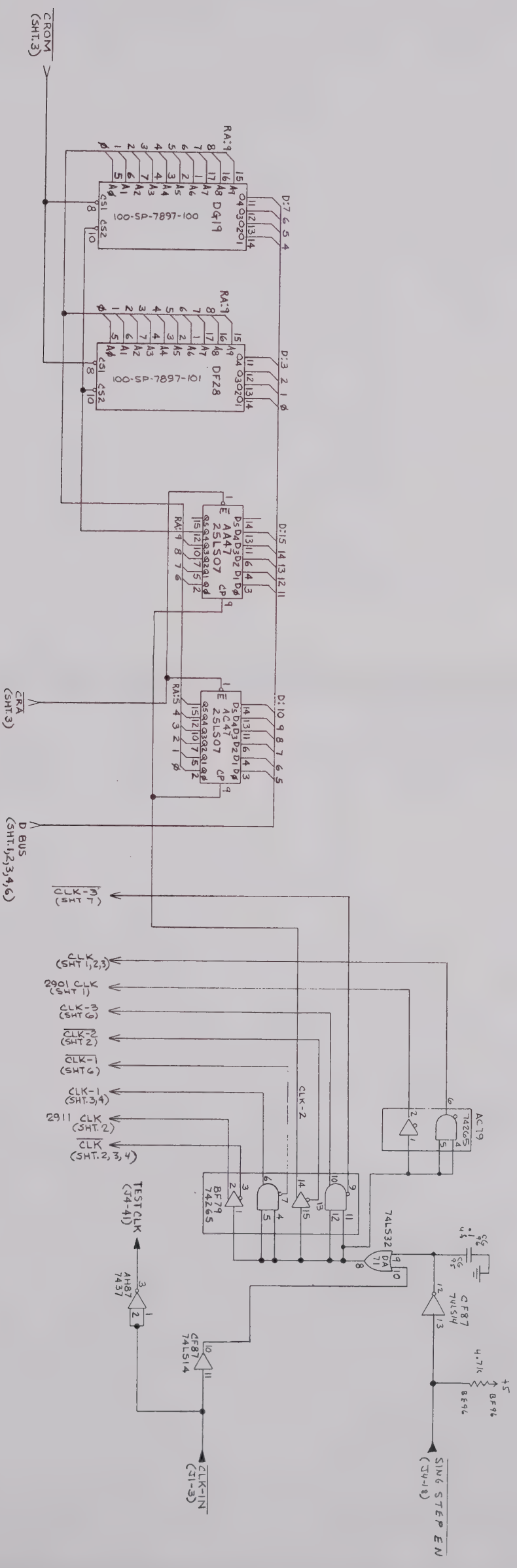


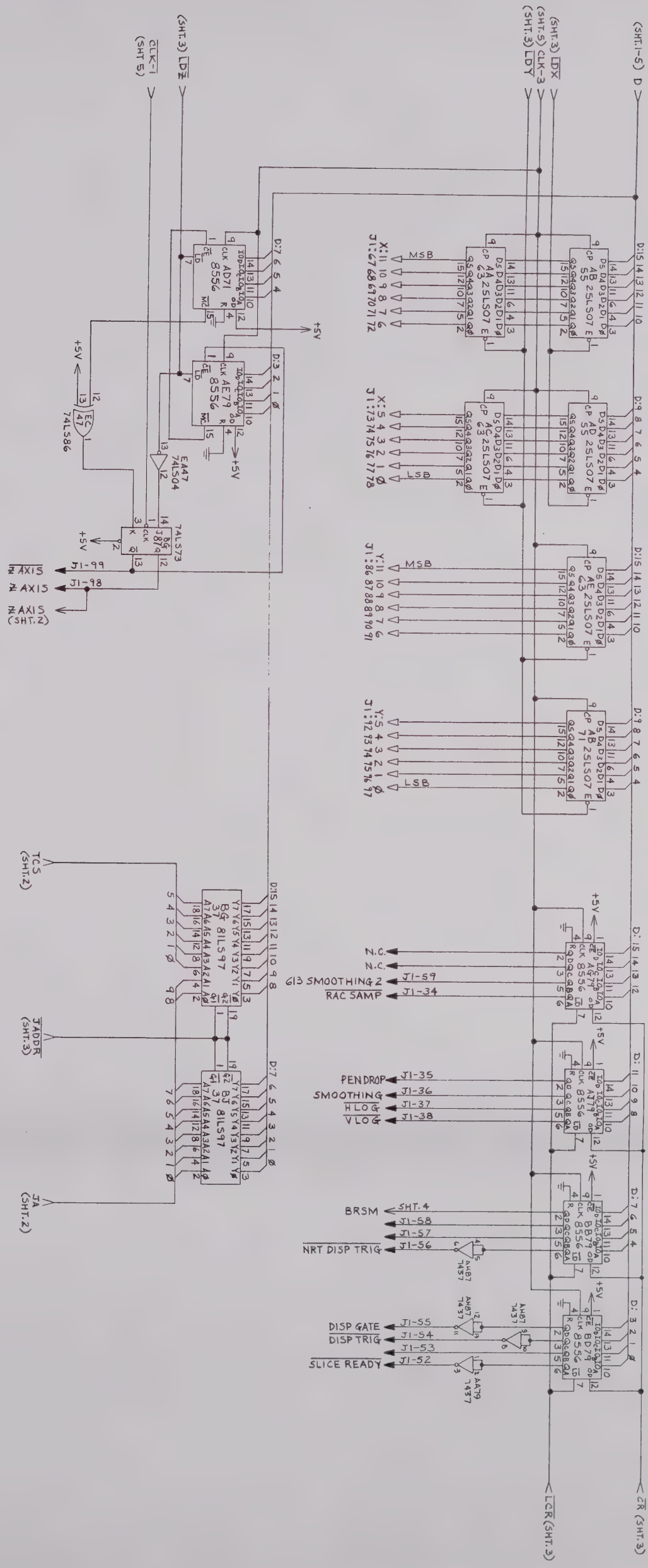


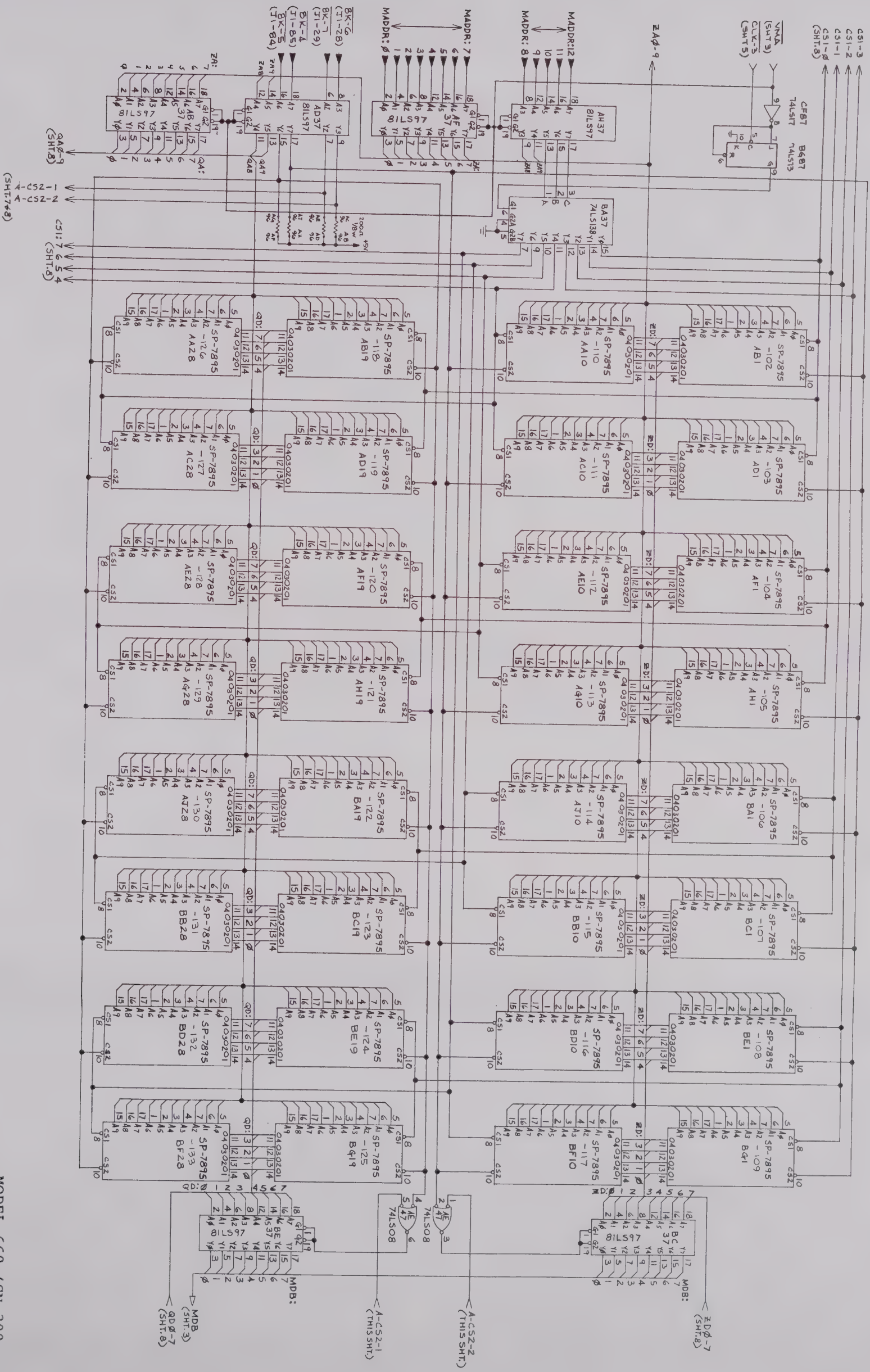






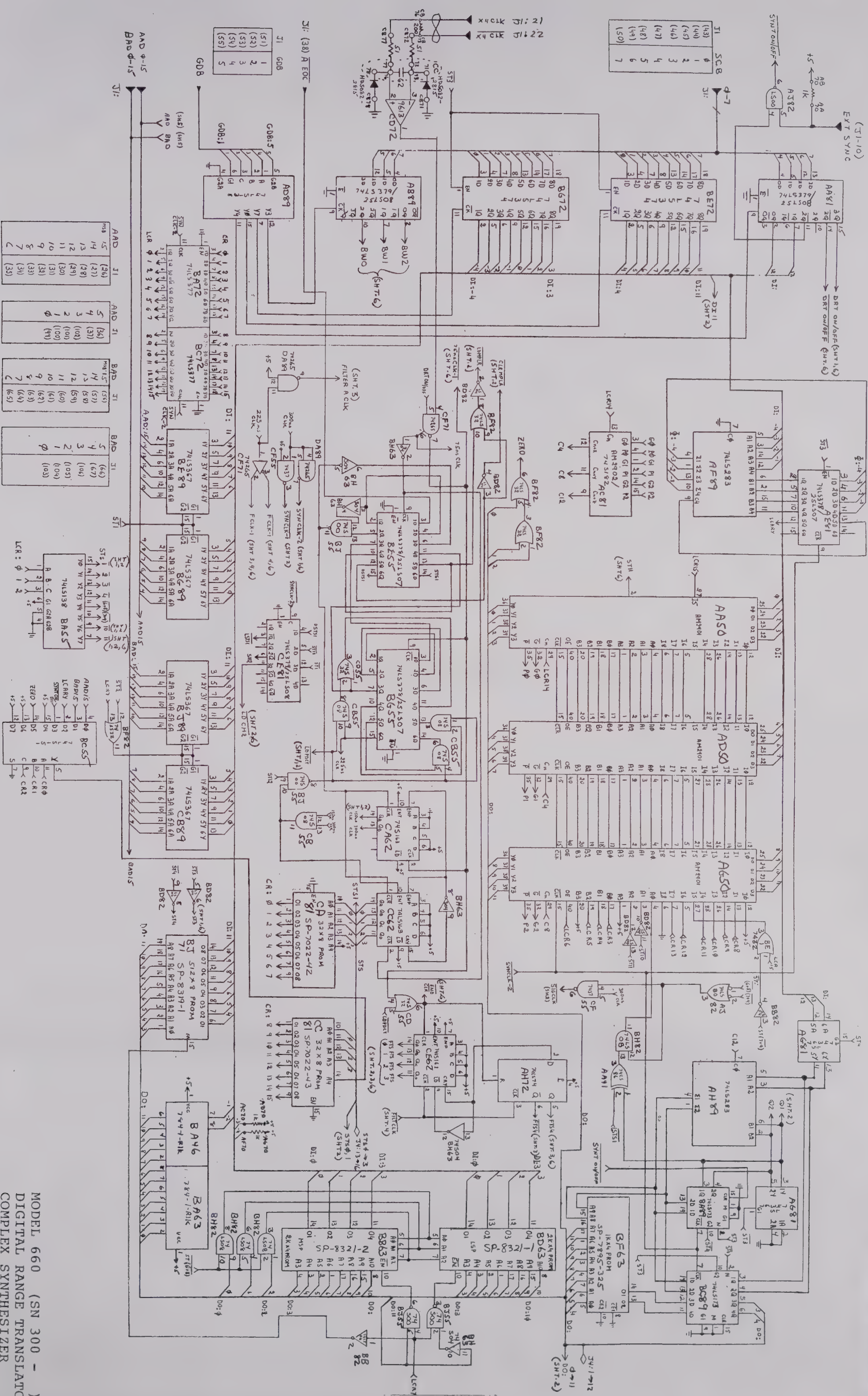


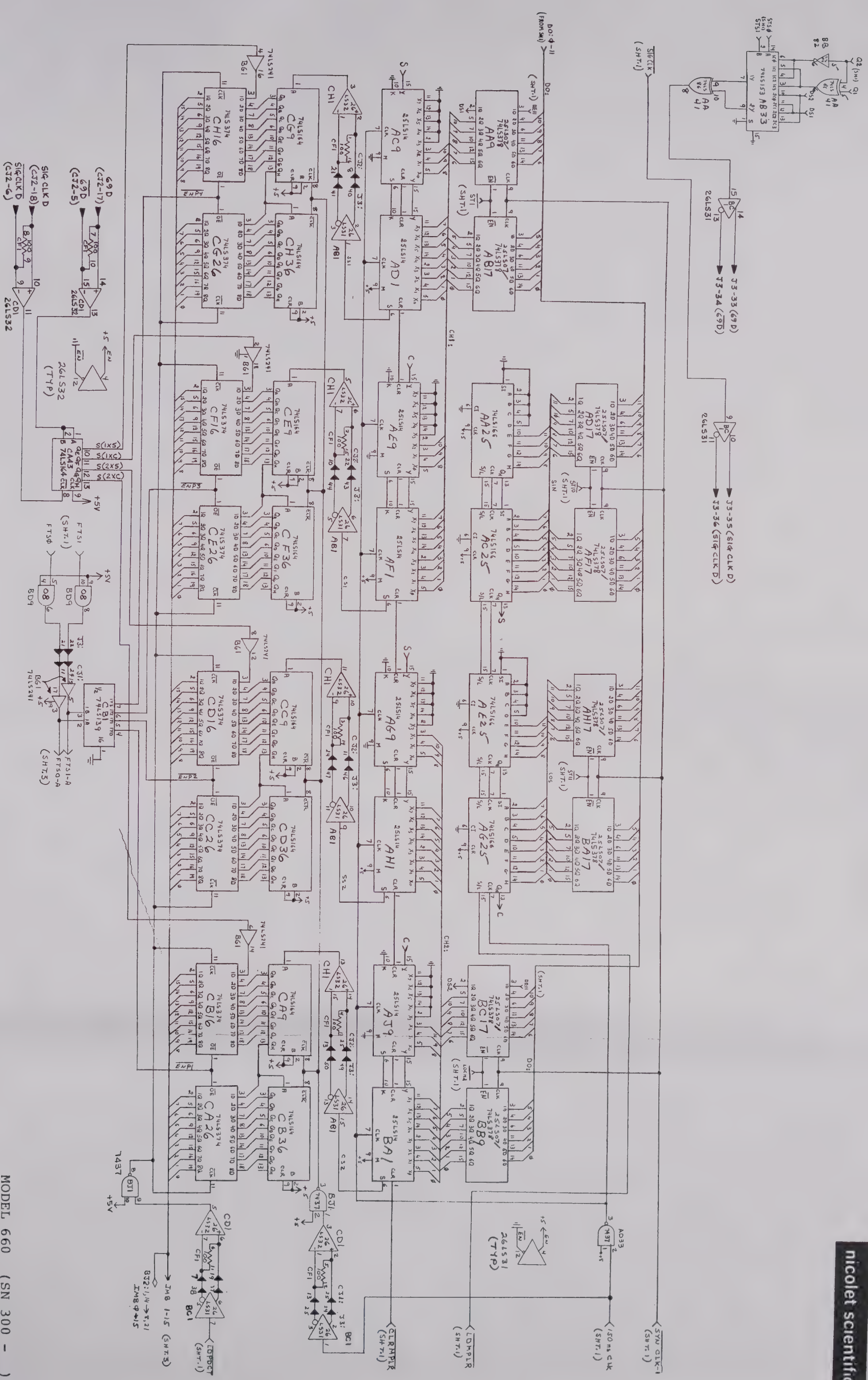


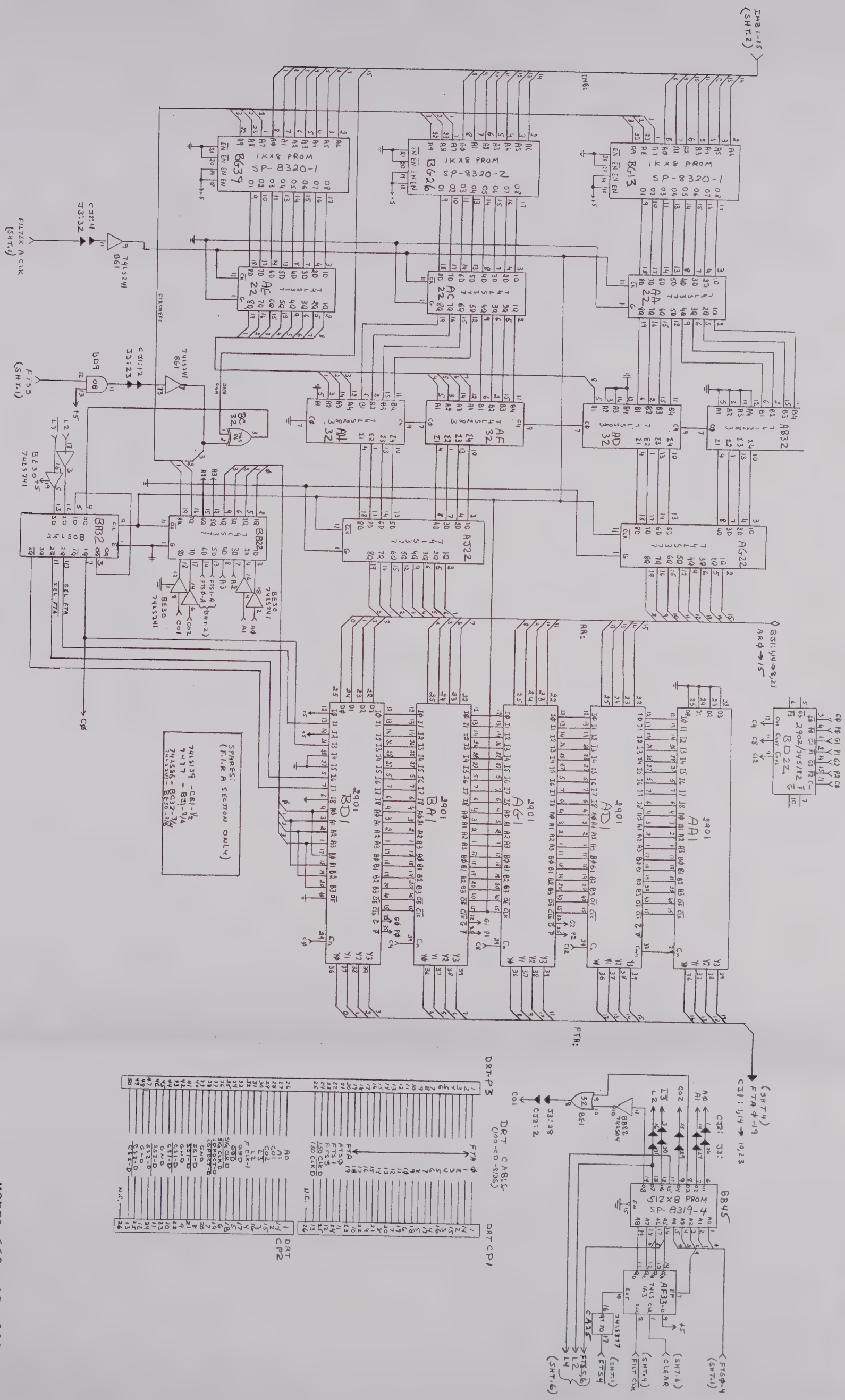


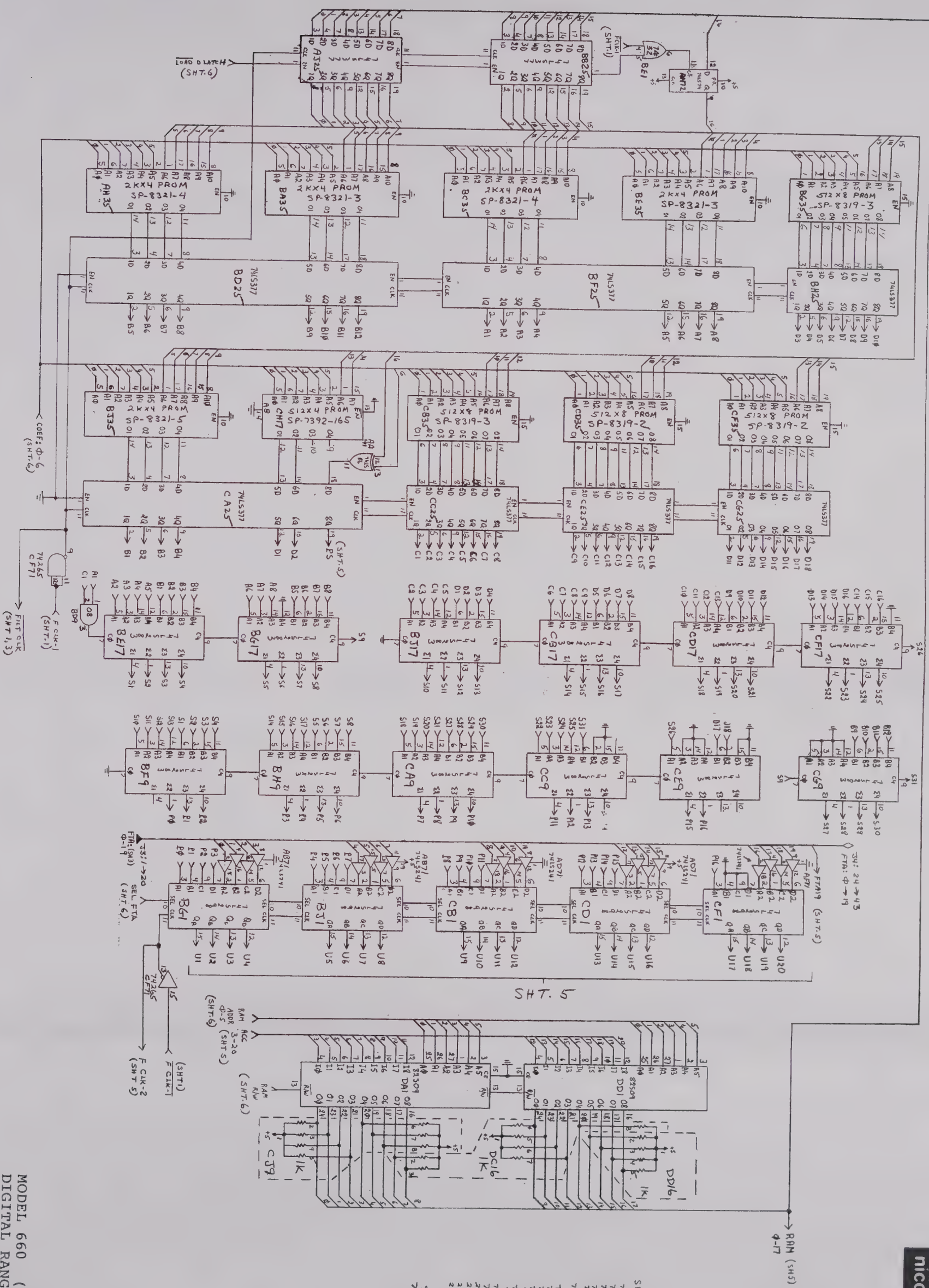


TEST MOD.
(J5-49)





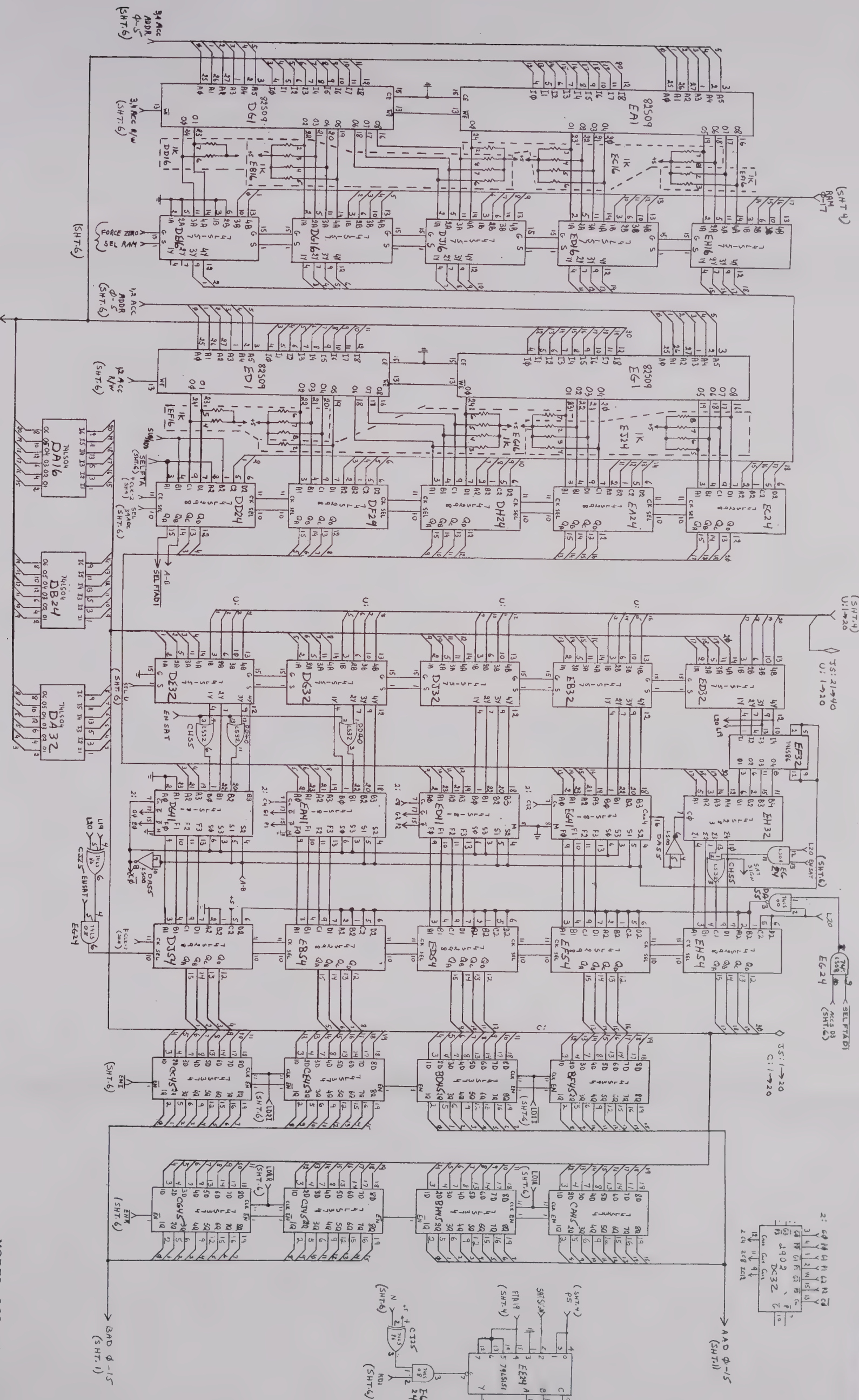


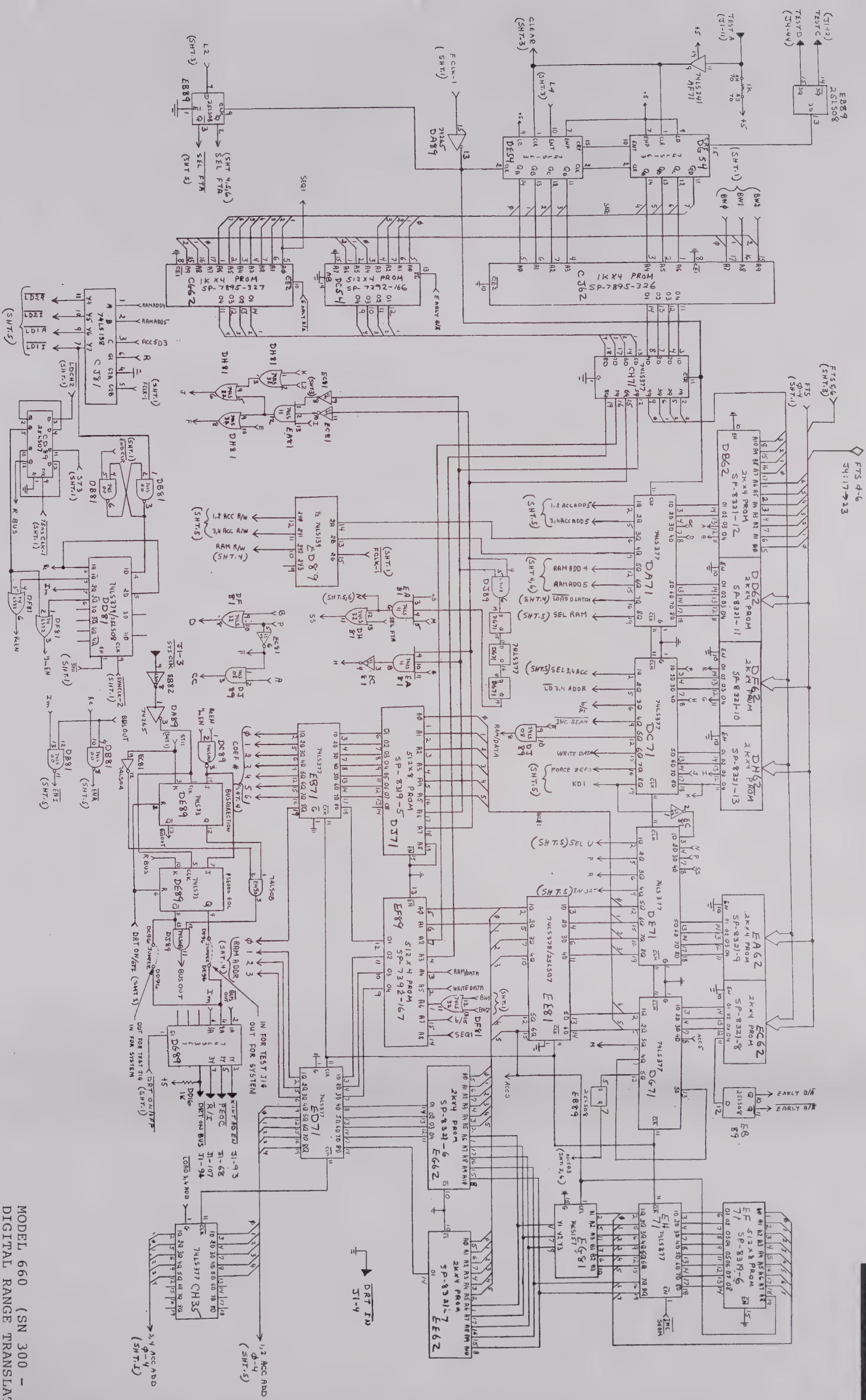


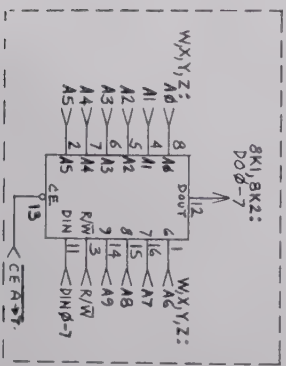
SPARE:

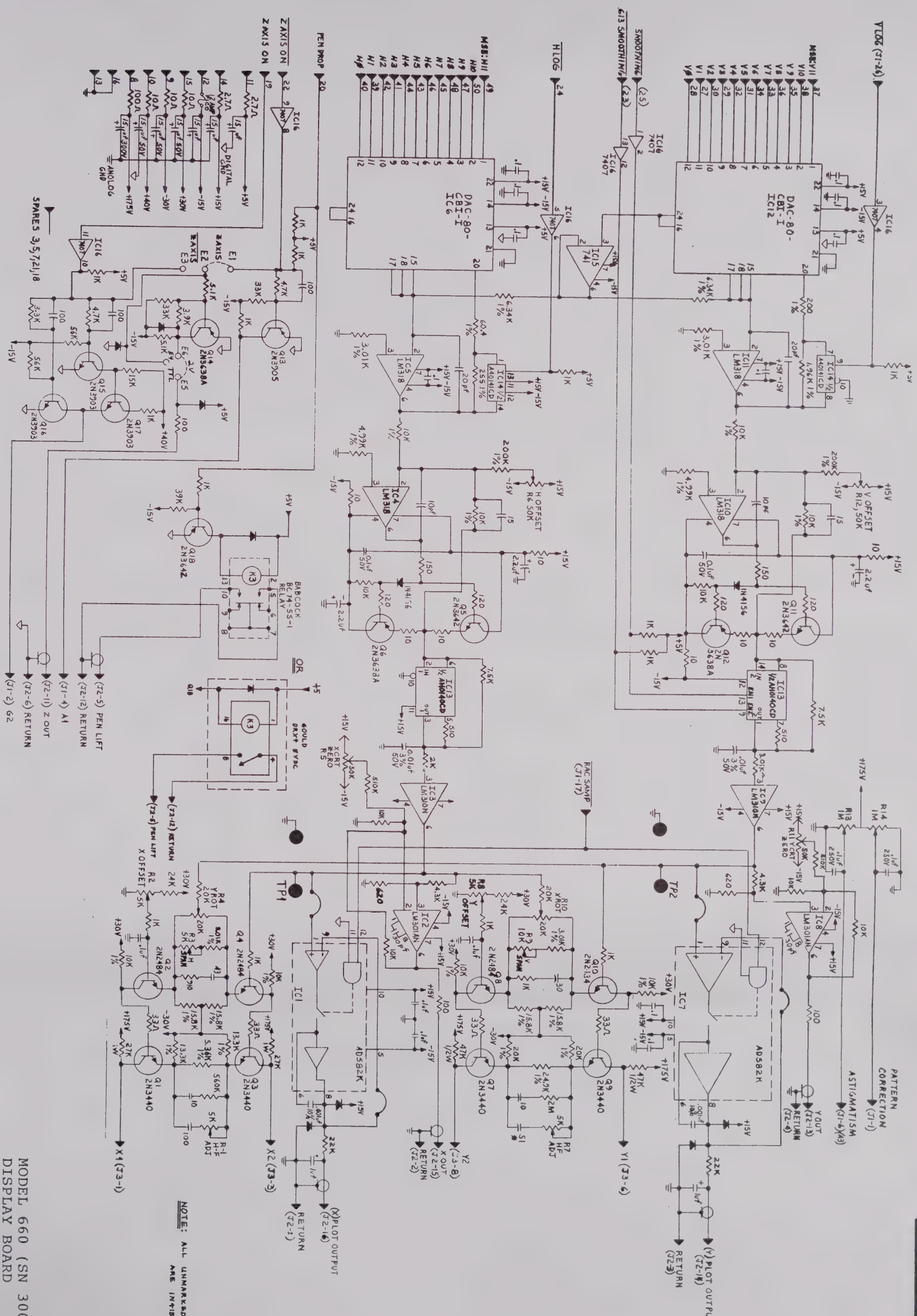
741500 - A3 83- 34
741500 - DA 83- 34
741500 - B882- 34
741500 - EC81- 16
7415231- AF71- 38
7437 - AD33- 34
7438 - GE- 14
743872 - CH55- 34
743873 - CD55- 34
74387 - CF55- 34
7445181- ED 89- 34
7445283 - AD 89- 34
7445283 - AB 89- 34
7445307 - CH 85- 36
7445307 - A 871- 36
7445308 - AB 89- 34
7445308 - CB 81- 34
7445308 - DB 81- 34
746133 - CD72- 36
746186 - CH 85- 34
1K - DO 16- 34
1K - EG 16- 34

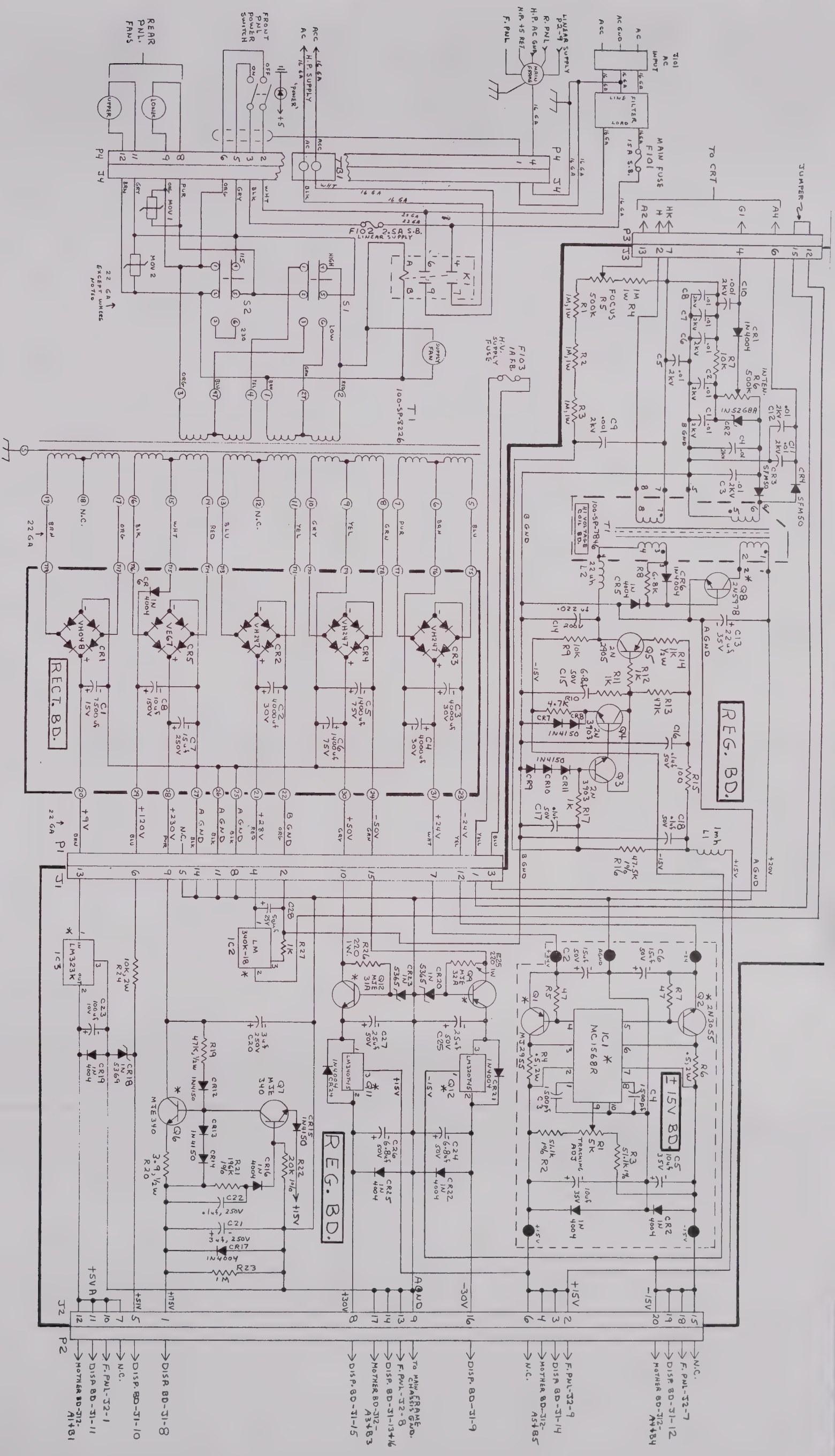
MODEL 660 (SN 300 -)
DIGITAL RANGE TRANSLATOR
F.I.R. (B) SECTION, PG.1
100-SC-8314
SHEET 4 of 6 REV E

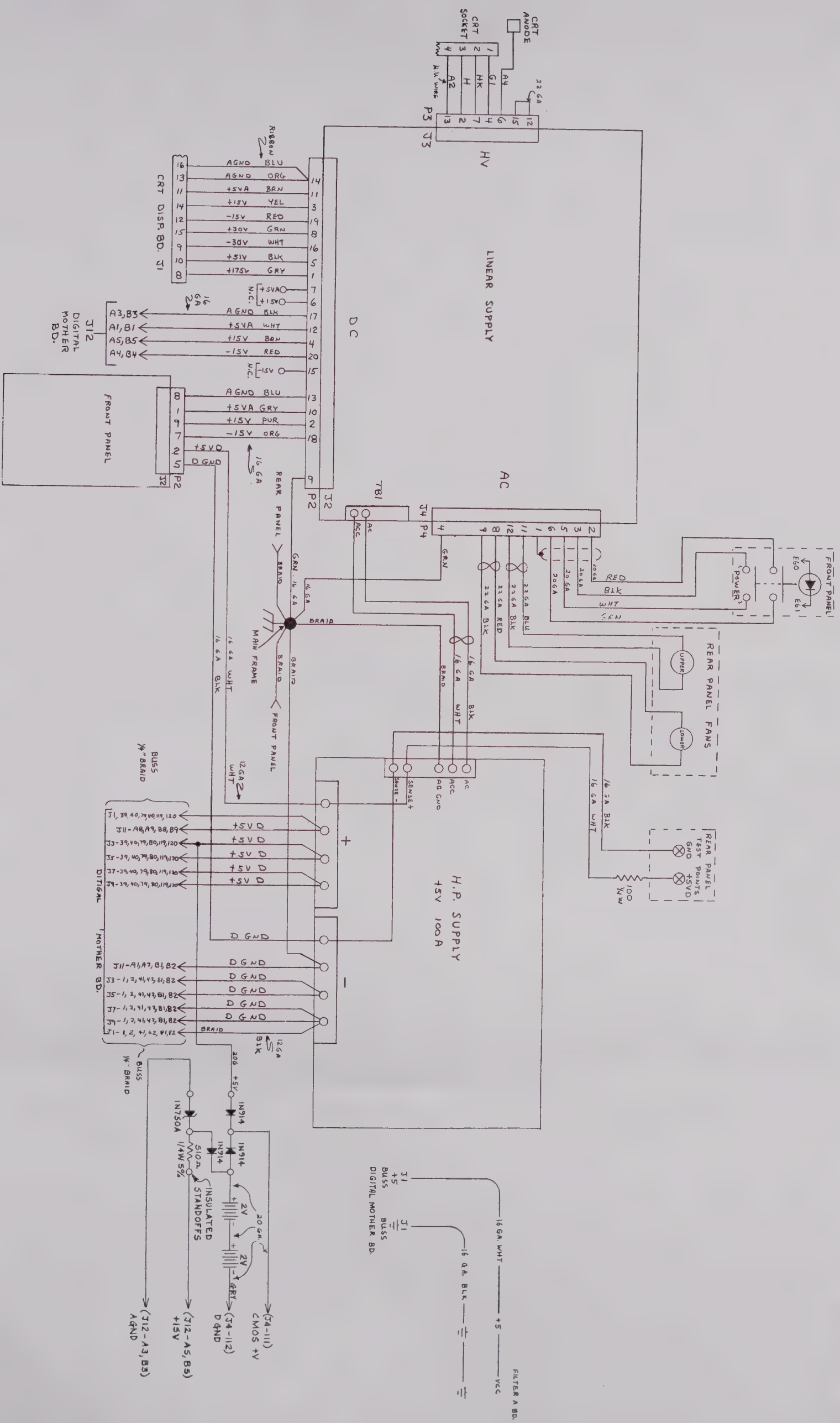




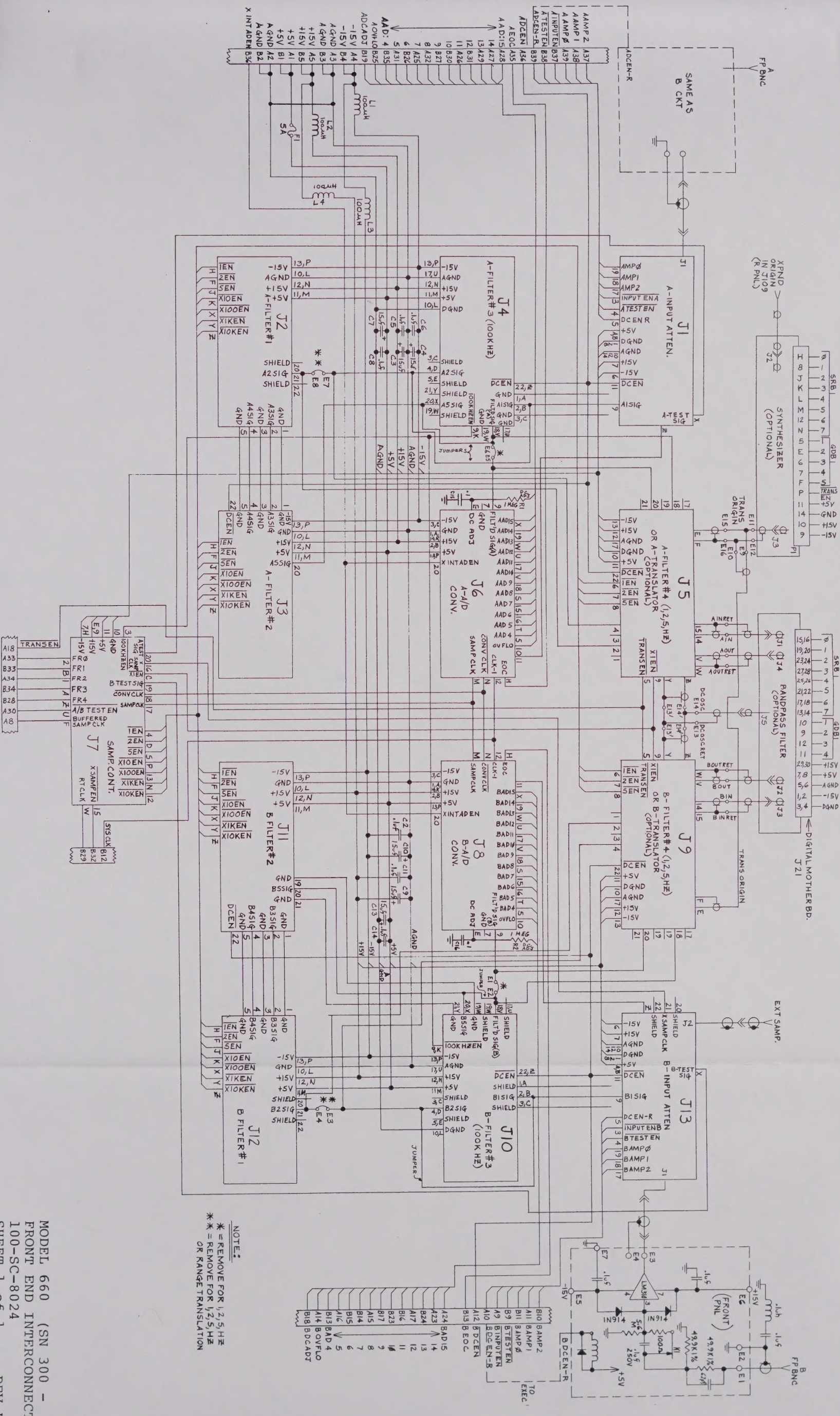












NOTE:
* = REMOVE FOR 1/2, 5 HZ
OR RANGE TRANSLATION

